# RESERVES OF HYDROCARBONS IN ALBERTA: A REVIEW OF CANADIAN PETROLEUM ASSOCIATION AND ALBERTA ENERGY RESOURCES CONSERVATION BOARD ESTIMATES AND METHODOLOGY

JAMES N. TANNER

CANADIAN ENERGY RESEARCH INSTITUTE

Research Report 86-2
November 1986
ISBN 0-920522-39-4

87-00591/

# RESERVES OF HYDROCARBONS IN ALBERTA: A REVIEW OF CANADIAN PETROLEUM ASSOCIATION AND ALBERTA ENERGY RESOURCES CONSERVATION BOARD ESTIMATES AND METHODOLOGY

James N. Tanner

ISBN-0-920522-39-4

CANADIAN ENERGY RESEARCH INSTITUTE
3512 - 33 STREET N.W.
CALGARY, ALBERTA
T2L 2A6

November 1986

Printed in Canada

Price: $25.00

The Canadian Energy Research Institute is a co-operative research organization sponsored by six parties: Energy, Mines and Resources Canada, the Alberta Department of Energy and Natural Resources, the Private Energy Research Association (composed of corporate and individual members from oil, gas, coal, electrical, nuclear energy and pipeline companies), The University of Calgary, the Ontario Ministry of Energy, and the Saskatchewan Department of Energy and Mines. The objectives of the Institute are to develop an economic research capability and to conduct studies that will assist industry and government in dealing with energy problems. The research program of the Institute is developed by a Board of Directors named by the sponsoring organizations. The content of the individual studies is, however, the responsibility of the authors.

## CONTENTS


LIST OF FIGURES ..... ix

LIST OF TABLES ..... xi

PREFACE ..... xiii

EXECUTIVE SUMMARY ..... xv

CHAPTER 1 INTRODUCTION ..... 1

CHAPTER 2 THE TECHNOLOGY OF RESERVES ESTIMATION ..... 5

2.1 Geology ..... 5

2.2 Engineering ..... 8

2.2.1 Natural Gas ..... 10
2.2.2 Oil ..... 12
2.2.3 Material Balance and Production History Techniques ..... 15

2.3 Summary ..... 17

CHAPTER 3 RESERVES ESTIMATION TECHNIQUES AND DEFINITIONS ..... 19

3.1 Advances in Estimation Techniques ..... 19

3.2 Improved Estimates as a Pool Matures ..... 19

3.3 Definitions of Oil and Gas Reserves ..... 21

3.3.1 Basic Definitions ..... 21
3.3.2 Established Reserves ..... 23
3.3.3 Proved Reserves (WPC) ..... 23
3.3.4 Proved Reserves (OSC) ..... 24
3.3.5 Which Definition to Use ..... 24

3.4 The Calculation of Remaining Established Reserves ..... 25

3.5 Changes in Methodology ..... 27

3.6 The Scope of Reserves Data in Alberta ..... 28

CHAPTER 4 THE ERCB METHODOLOGY ..... 33

4.1 Oil Reserves ..... 33

4.1.1 Prorationing ..... 33
4.1.2 Estimation Procedure ..... 34
4.1.3 Periodic Reviews ..... 34
4.1.4 Maximum Rate Limitations ..... 36

4.2 Gas Reserves ..... 37

4.2.1 Estimation Methodology ..... 37
4.2.2 Gas Reserves Estimates Over Time ..... 37

CHAPTER 5 THE CPA METHODOLOGY ..... 43

5.1 Estimation Methodology ..... 43

5.2 Resource Constraints ..... 44

5.3 Estimates Over Time ..... 44

5.3.1 Oil ..... 44
5.3.2 Gas ..... 45
5.3.3 Area Threshold ..... 45
5.3.4 Changing Guidelines ..... 45
5.3.5 Presentation ..... 46

CHAPTER 6 CPA AND ERCB ESTIMATES ..... 47

6.1 Estimates of Established Reserves of Conventional Crude Oil ..... 47

6.2 Estimates of Marketable Natural Gas ..... 53

6.3 Oil Sands ..... 56

6.4 In-Situ Crude Bitumen Reserves ..... 57

6.5 Natural Gas Liquids ..... 58

6.6 Sulphur ..... 63

6.7 Ultimate Potential ..... 63

6.7.1 ERCB ..... 63
6.7.2 CPA ..... 64

CHAPTER 7 CONCLUSION ..... 73

7.1 Estimations ..... 73

7.2 Summary of Results ..... 74

APPENDIX A JOINT TASK FORCE ON UNIFORM RESERVES TERMINOLOGY NOVEMBER 1978 ..... 79

APPENDIX B NATIONAL POLICY No. 2-B GUIDE FOR ENGINEERS AND GEOLOGISTS SUBMITTING OIL AND GAS REPORTS TO CANADIAN PROVINCIAL SECURITIES ADMINISTRATORS ..... 91

APPENDIX C ERCB OIL REVIEW ..... 101

APPENDIX D ALBERTA GAS RESERVE TRENDS 31 DECEMBER, 1985 ..... 107

APPENDIX E DECLINE CURVES ..... 119

APPENDIX F CLASSIFICATION AND NOMENCLATURE SYSTEMS ..... 123

## LIST OF FIGURES


2.1 Porosity ..... 6

2.2 Stratigraphic Trap ..... 7

2.3 Structural Trap ..... 8

2.4 Occurrence and Classification of Gas Reserves ..... 11

3.1 Estimates of Established Reserves ..... 20

3.2 Crude Oil: Historical Record of Remaining Established Reserves in Canada ..... 26

3.3 ERCB Recording Format ..... 30

3.4 ERCB: Additions to Established Reserves of Conventional Crude Oil, 1951-1985 ..... 31

4.1 ERCB Form O-38 ..... 35

4.2 ERCB: Additions to Established Reserves of Marketable Gas, 1951-1985 ..... 39

4.3 ERCB Table C-3 ..... 40

6.1 Remaining Established Oil Reserves in Alberta ..... 47

6.2 Additions to Established Oil Reserves in Alberta ..... 49

6.3 Additions to Established Oil Reserves in Alberta, ERCB ..... 50

6.4 Additions to Established Oil Reserves in Alberta, CPA ..... 50

6.5 Additions to Established Oil Reserves in Alberta due to New Discoveries ..... 52

6.6 Additions to Established Reserves of Marketable Gas in Alberta ..... 53

6.7 Remaining Established Reserves of Marketable Gas in Alberta ..... 54

6.8 Additions to Established Reserves of Marketable Gas in Alberta, ERCB ..... 55

6.9 Additions to Established Reserves of Marketable Gas in Alberta, CPA ..... 55

6.10 Reserve Additions due to New Discoveries, Gas ..... 56

6.11 The Production of Natural Gas Liquids ..... 62

6.12(a) ERCB Table 8-1 ..... 65

6.12(b) ERCB Figure 8-1 ..... 66

6.13(a) ERCB Table 8-2 ..... 67

6.13(b) ERCB Figure 8-2 ..... 68

6.14(a) CPA Table 17 ..... 69

6.14(b) CPA Table 23 ..... 70

## LIST OF TABLES


| | | |
|---|---|---|
| E.1 | A Comparison of ERCB and CPA Estimates of Remaining Established Reserves as of December 31, 1985 ..... | xvi |
| 2.1 | Average Oil Reservoir Parameters for Alberta ..... | 9 |
| 2.2 | Range of Factors Used in Calculating Gas Reserves in Alberta ..... | 9 |
| 2.3 | Oil Density Classifications ..... | 12 |
| 2.4 | Oil Viscosity Classifications ..... | 13 |
| 2.5 | Average Production Rates ..... | 13 |
| 3.1 | Former Definitions Used to Estimate Reserves ..... | 27 |
| 6.1 | Established Reserves of Synthetic Oil, Comparison ..... | 57 |
| 6.2 | In-Situ Reserves ..... | 59 |
| 6.3 | Pentanes Plus Reserves ..... | 59 |
| 6.4 | Liquified Petroleum Gases Reserves ..... | 60 |
| 6.5 | Comparison of Natural Gas Liquids Reserves as Presented by the ERCB and CPA ..... | 61 |
| 6.6 | Reserves of Sulphur ..... | 63 |

## Preface

This Research Report was done during the spring and summer of 1986 and completed in October of that year. The Institute is grateful for the helpful comments on earlier drafts of the Research Report by a three-member Advisory Committee comprised of two representatives from the Energy Resources Conservation Board and one representative from the Canadian Petroleum Association.

Thanks are due to those officials within the ERCB and CPA who provided valuable information and were very patient as they explained many of the complexities of reserve estimates to the author. The author is, however, solely responsible for the conclusions drawn, and for any errors or omissions which are in the report.

Thanks are also due to Albert Balasch who explained many technical engineering points, to Lise Taylor who provided editorial assistance, to Brian Cox and Anita Duclos for assistance in graphics presentation, to Donna Zimmerman who typed the final document and the many drafts which preceded it, and to Anthony E. Reinsch, whose comments and suggestions were very valuable.

## EXECUTIVE SUMMARY

The estimation of hydrocarbon reserves is, by its nature, an inexact science. Initial assessment of the volumetric size of a reservoir is based on assumptions regarding the areal extent of the reservoir, its porosity and net pay thickness, and the characteristics of the hydrocarbons found in the reservoir. Errors in assessment of these variables and adjustments made in light of production history will have an impact on the ultimate recoverable reserves estimate for a given reservoir. Changes in economic variables will further affect the estimate of reserves which are deemed recoverable under current and expected market conditions. Despite the inaccuracies inherent in reserves estimation, the results form a critical component in the strategic and financial planning of the companies holding the reserves and, more broadly, in the development and implementation of provincial and federal energy policy.

This study is designed as a handbook for those engaged in the use and analysis of petroleum and natural gas reserves data. A discussion of the mechanics of reserves estimation and the various techniques and definitions underlying the assessment of hydrocarbon reserves provides the analyst with an understanding of the methodology upon which reserves estimates are based.

The study focuses on the hydrocarbon reserves estimates generated for Alberta by the Alberta Energy Resources Conservation Board (ERCB) and by the Canadian Petroleum Association (CPA). These organizations provide hydrocarbon reserves estimates for Alberta dating from the beginning of active oil and gas development in the province. Historical differences between the two reserves series are identified and discussed, with explanations for the differences provided where possible to assist the reader in selecting the appropriate series for his or her purposes. However, no attempt is made to assess the relative accuracy or quality of the series. Given the inexactness of the exercise, it is clear that analysts and policy makers benefit from the checks and balances provided by the comparison of independent estimates of hydrocarbon reserves.

Table E.1 provides the most recent annual reserves estimates generated by the two organizations, for the various hydrocarbon categories. The estimates are quite comparable, given the independent nature of the estimates and the procedural differences between the two organizations. Significant differences exist in the estimates of natural gas liquids reserves and in-situ crude bitumen reserves.

TABLE E.1

A COMPARISON OF ERCB AND CPA ESTIMATES OF
REMAINING ESTABLISHED RESERVES AS OF DECEMBER 31, 1985

| | E R C B | C P A |
|---|---|---|
| | (millions of cubic metres) | |
| Conventional Crude Oil | 648.5 | 648.7 |
| Pentanes Plus | 120.1 | 129.2 |
| Propane | 125.6 | |
| Butanes | 70.4 | 163.9 |
| Ethane | 321.0 | |
| Bitumen (In-Situ) | | |
| Initial Established | 72.2 | 146.1 |
| Remaining Established | 59.6 | 136.5 |
| Oil Sands | 282.0 | 256.2 |
| | (thousand tonnes) | |
| Sulphur | 76.8 | 83.4 |
| | (billion cubic metres) | |
| Marketable Natural Gas | 1,768.3 | 1,827.1 |

SOURCE: Canadian Petroleum Association
Alberta Energy Resources Conservation Board
Canadian Energy Research Institute

In conclusion, the following recommendations are provided regarding future estimation of hydrocarbon reserves:

(1) That the "established reserves" definition is a superior method of presenting reserves data for policy making purposes, and that the ERCB and CPA resist overtures being made by certain observers in the United States that a more conservative definition be adopted;

(2) That the ERCB begin to publish oil reserves by year of discovery, consistent with the format provided by the CPA;

(3) That the ERCB and CPA reconsider publishing and/or collecting data on the basis of reserves adjustments, separate from other additions categories;

(4) That the ERCB and CPA present estimates of natural gas liquids in a manner which allows simple comparison; and

(5) That the estimates of in-situ bitumen done by the ERCB and the CPA be discussed by these two organizations to discover the reasons for the vast difference in estimates.

# Chapter 1

## INTRODUCTION

The recent history of the oil industry has been much like a roller coaster. Tremendous upswings in price and activity have been followed by precipitous declines. In such an environment it is very difficult to establish a consistent and accurate estimate of reserves of oil.

Not only are accurate estimates difficult to make, but reserves classifications are complex and often difficult to understand. An interesting example of this was brought out by a former Minister of Energy, Mines and Resources.[1] In a speech to the Canadian Institute of Mining and Metallurgy on June 2, 1971, he said, "Canada's total oil reserves were 469 billion barrels at the end of 1970 while total natural gas reserves were 725 trillion cubic feet. At 1970 rates of production, these reserves represent 923 years supply for oil and 392 years for gas." Unfortunately, the Honourable Minister was referring to ultimate potential instead of established or proven reserves. Such misunderstandings are not uncommon and the topic of reserves has been a contentious political issue more than once over the history of the industry.

Alberta alone accounts for approximately 80 percent of the reserves of oil in Canada.[2] In Alberta there are two major sources of data on petroleum and natural gas reserves. The organizations which publish these data are the Alberta Energy Resources Conservation Board (ERCB), an agency under the auspices of the Government of Alberta, and the Canadian Petroleum Association (CPA), an industry association comprised mainly of integrated oil and gas companies.

These two organizations publish oil and gas reserves estimates for Alberta dating from the beginning of active oil and gas development in the province. These independent reserves estimations provide two complete time series of established reserves and reserves additions for the spectrum of hydrocarbons produced in Alberta. The differences between these series are of interest and will be considered in this report.

It is not the role of this paper to attempt to assess the accuracy or propriety of these estimates but rather to discuss the definitions, techniques and processes underlying the formulation of these estimates. The intent of this review is to provide a guide to users, so that the data series can be better understood and utilized in analytical work. The focus of this guide is to introduce the topic of reserves and reserves data to the less experienced user.

The analysis is divided into seven chapters. In Chapter 2, a general description of standard geological and engineering techniques used in estimating reserves is provided. In Chapter 3, reference is made to the accuracy of estimates over the producing life of a particular well or pool. A possible source of discrepancy in reserves estimates compiled by different organizations is the use of differing definitions or interpretations of reserves. These differences are discussed in Chapter 3 and a review of a recent paper on world standardization of these definitions is provided, including a discussion of the two major systems which are presently in use worldwide.

In Chapter 4, a description of the procedures used by the ERCB to estimate oil and gas reserves is provided. In Chapter 5, a description of the techniques used by the CPA is presented.

Chapter 6 contains published historical data for established remaining reserves of crude oil, marketable natural gas, bitumen, synthetic oil, pentanes plus, and sulphur, from both the CPA and the ERCB. A graphical display of these data is also presented.

Also in Chapter 6, an analysis of the definitions, techniques of estimation and policies employed by the two organizations is presented. The purpose of this section is to outline the factors which have probably affected the reserves estimates over time and to provide information to researchers on the possible statistical biases incorporated within the data.

In the conclusion, the general differences between the two data sets are summarized and recommendations are made concerning presentation of the data. Generally it is felt that Alberta benefits from having two organizations involved in estimating such an elusive and inexact variable as the volume of hydrocarbon resources.

**Footnotes**

[1]Speech given to Canadian Institute of Mining and Metallurgy, Banff, Alberta, June 2, 1971 by the Honourable Joe Green, Minister of Energy, Mines and Resources.

[2]The actual amount depends upon the definitions and estimates which are used.

## Chapter 2

## THE TECHNOLOGY OF RESERVES ESTIMATION

Estimates of hydrocarbon reserves are based upon the sciences of geology and engineering. A scientific approach to assessing reserves makes optimal use of the data and information available. The estimation process usually involves at least a geologist and/or technician and a petroleum engineer.

### 2.1 Geology

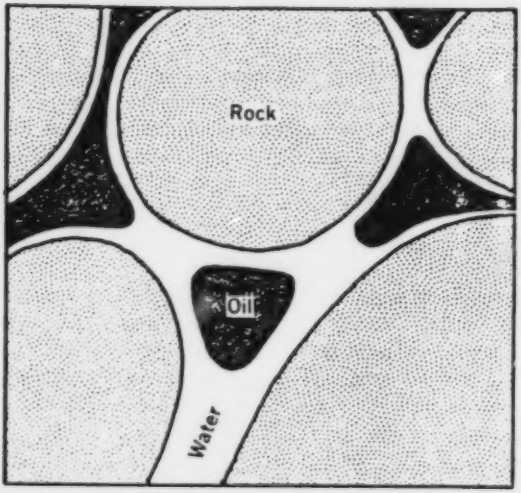
The geologist begins the investigation by establishing the geologic setting. Hydrocarbons are generally thought to be found only in sedimentary rocks. Sedimentary means that the igneous rocks of the earth's crust are eroded by wind, rain, water and fracturing of the crust and then either settled out as solid grains or as dissolved minerals from solution. Hydrocarbons are believed to be formed when organic material, deposited in the sedimentary rock, is subjected to heat and pressure of overburden material. It should be recognized that not all sedimentary deposits are found in a salt water, marine type environment. Sedimentary deposits have also been found under continental fresh water and even dry land environments.

Sedimentary rock can be very dense and similar in texture to glass or it may be porous and similar to sponge or concrete. The pores in sedimentary rock form the space where hydrocarbons are able to accumulate. A large collection of pores over a large area forms the petroleum reservoir. Typical porosity can range from 0 (zero) percent to 35 percent of total rock volume. Porosity is presented in Figure 2.1.

In order for the reservoir accumulation of hydrocarbons to be productive, the pores must be inter-connected by flow channels. Pores in concrete are not connected while the pores in a sponge are well connected. The measure of the ability of hydrocarbons to flow from pore to pore is referred to as permeability. An assessment of the productive capability of a reservoir is made by measuring the permeability of the reservoir rock.

FIGURE 2.1

POROSITY




SOURCE: Modern Petroleum, Bill D. Berger and Kenneth E. Anderson

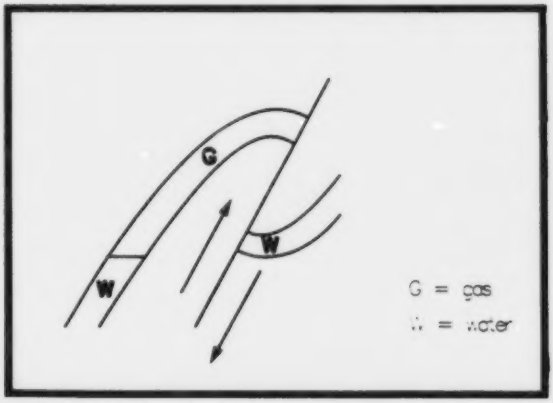
Initially, a geologist determines if there is a chance that rocks underlying an area are porous and permeable. The preliminary work involves studying outcrops of rocks in mountains and areas not covered by glacial till. The geologist gets further information as the exploration program develops, wells are drilled and underlying rock samples are analyzed. Once the geologist determines the type of sedimentary rock that exists, he can assess the probability that a porous, permeable and hydrocarbon-filled reservoir also exists. Once important consideration for the geologist is the potential size of the hydrocarbon bearing areas. A sedimentary rock basin could extend over an area as large as a large Canadian province. A single reservoir of hydrocarbons in a sedimentary basin can be as small as a few acres or large enough to cover several townships. Commercial production has been obtained from reservoirs ranging in depth from 1 to 2 feet thick, to 500 feet thick or more.

Once the geologist has established that porous reservoirs exist, he must then determine the most likely locations for the accumulations. That is, he must find locations where the accumulations can become trapped. The two most common types of traps are the stratigraphic trap and the structural trap.

A stratigraphic trap is found where the porous, permeable rock changes to non-porous and impermeable rock so that the fluids become trapped at the porosity pinchout. A stratigraphic trap is illustrated in Figure 2.2. The term 'fluids' is used to indicate that reservoir rock is usually all or partially filled with water, gas or oil. The portion of pore space which is not filled with water is occupied by hydrocarbons. Hydrocarbons, being lighter than water, accumulate in the structurally higher portions of the pore space.

FIGURE 2.2

STRATIGRAPHIC TRAP

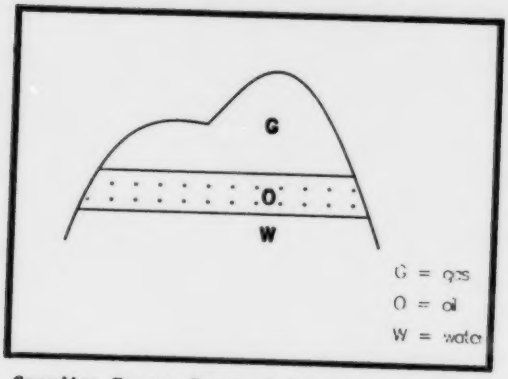



SOURCE: Canadian Energy Research Institute

Structural traps exist in areas where for various reasons the sedimentary layers of the earth's crust are distorted into waves, bumps, or hills. If a porous, permeable layer exists within the hill or overlays the hill and is distorted by it, then there is a structural cause for the hydrocarbons to separate from the water and accumulate at the highest elevation of the structure. A structural trap is illustrated in Figure 2.3.

FIGURE 2.3

STRUCTURAL TRAP




SOURCE: Canadian Energy Research Institute

Both the deposition of the sedimentary rock and the structural shape tend to show regular patterns and trends. One can see these sorts of trends and patterns by observing the earth's current surface features, such as hills, valleys, lakes, etc. Successful exploration for commercial hydrocarbon deposits is greatly assisted by the ability of the geologist to forecast and project these ancient patterns and locations of potential hydrocarbon accumulations.

## 2.2 Engineering

The function of the geologist is qualitative and quantitative. While the geologist is aware of the economics pertaining to the exploration for and production of hydrocarbons, it is an engineering function to place a value on the reserves found by the geologist. The function of the petroleum reservoir engineer is mostly quantitative.

A petroleum reservoir engineer's first objective is to determine the size of the reservoir. Once the size of reservoir is established, the engineer is able to estimate the percent of oil-in-place that could be recovered. To calculate volume-in-place the engineer must first determine, in conjunction with the geologist, the areal extent of the reservoir, the net pay thickness, the porosity of the reservoir, and the initial water situation. Typical parameters for reservoirs in Western Canada are shown in Table 2.1.

TABLE 2.1

AVERAGE OIL RESERVOIR PARAMETERS FOR ALBERTA

| Factor | Metric | Imperial |
|---|---|---|
| Net Pay Thickness - metres/feet | 5 | 16.4 |
| Porosity - Percent | 25 | 25 |
| Water Saturation - percent | 30 | 30 |
| Oil Shrinkage (percentage oil at surface) | 75 | 75 |
| Original oil-in-place | | |
| - cubic metres of oil per hectare per metre | 1464 | - |
| - barrels per acre per foot | - | 1018 |

SOURCE: Canadian Energy Research Institute

TABLE 2.2

RANGE OF FACTORS USED IN CALCULATING GAS RESERVES IN ALBERTA

| Factor | Unit | Range |
|---|---|---|
| Average Pay Thickness | metres | 1-150 |
| Area | hectares | 15-400 000 |
| Porosity | fraction | 0.02-0.35 |
| Water Saturation | fraction | 0.06-0.60 |
| Pressure | kilopascals | 1 400-34 000 |
| Temperature | K | 290-390 |
| Reservoir recovery | fraction | 0.40-0.90 (Ave. 0.74) |
| Surface recovery | fraction | 0.40-0.98 (Ave. 0.80) |

SOURCE: Energy Resources Conservation Board Staff

The foregoing typical numbers represent original hydrocarbon volume-in-place. As a general estimate one can expect to recover 20 to 70 percent of gas-in-place and anywhere from 1 to 60 percent of oil-in-place. A major problem for petroleum engineers is to establish with reasonable accuracy (plus or minus 5 percent) just what the ultimate recovery is likely to be.

### 2.2.1 Natural Gas

Natural gas is found in three different states: non-associated gas, associated gas and solution gas. Associated gas and solution gas are found with oil, while non-associated gas is found alone. The diagrams in Figure 2.4 illustrate these different occurrences of gas.

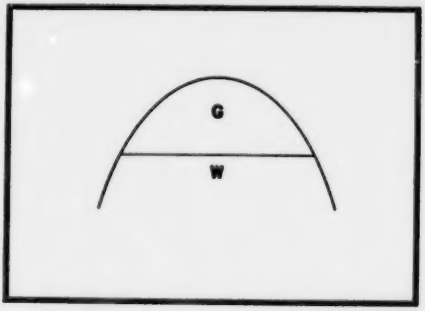
In order to calculate the volume of natural gas which would be recovered from a reservoir, material balance methods are used which are based upon perfect gas laws. Early recovery calculations which are based on gas laws, and which are undertaken before any actual production testing and history are available, are often found to be in error. This error results from the fact that information on porosity and permeability is obtained from the wellbore which represents, at best, a very small sample (about four inches in diameter) of the reservoir rock. Rock variations in the area surrounding the wellbore for a radius of several hundred metres will determine the production performance and ultimate recovery from the well.

An accurate assessment of the ultimate volume of gas to be recovered is a major concern. The engineer obtains pressure measurements in the wellbore on an annual basis and compares the drop in pressure to the production taken from the reservoir. After several pressure versus production data points are obtained, a pattern of pressure depletion versus production can be established. The engineer can then extrapolate the actual historical pressure versus production performance into the future and calculate the volume of gas that will ultimately be recovered before the pressure depletes to a level which is incapable of sustaining a commercial production rate. Gas recovery by natural pressure depletion (i.e., gas expansion) usually exceeds 50 percent of gas-in-place.

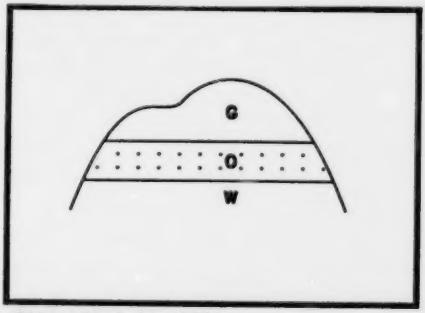
FIGURE 2.4

OCCURRENCE & CLASSIFICATION OF GAS RESERVES

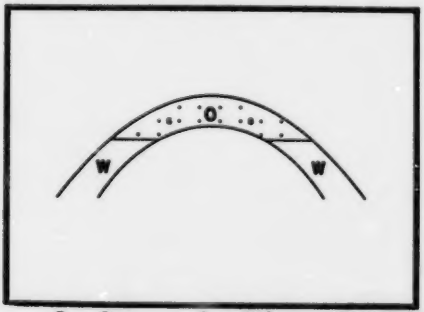
- Non-associated




- Associated




-Solution Gas (dissolved in oil)




G = Gas O = Oil W = Water

SOURCE: Canadian Energy Research Institute

### 2.2.2 Oil

Ultimate recovery of original oil-in-place depends upon several factors and is a much more complex science than recovery from a gas reservoir. Oil recovery depends upon the density of the oil, the viscosity of the oil, and the possible drive systems and nature of the specific reservoir. The first consideration in oil recovery is the type of oil, meaning the density of the oil in the reservoir. Typical types of oil are described in Table 2.3.

TABLE 2.3

OIL DENSITY CLASSIFICATIONS

| | Density of the Oil | |
|---|---|---|
| | Metric (kg/metre) | American (°API) |
| Very Light | less than 837 | over 37.5 |
| Light | 837 to 890 | 27.5 to 37.5 |
| Medium | 890 to 934 | 20 to 27.5 |
| Heavy | 934 to 983 | 12.5 to 20 |
| Very Heavy | over 983 | less than 12.5 |

SOURCE: Canadian Energy Research Institute

The ability or tendency of a given type of oil to flow depends upon the viscosity of the oil. Usually, viscosity is directly related to density. Heavy oils exhibit a high viscosity while light oils exhibit a low viscosity. The lower the density the lower the viscosity and the greater the tendency of the oil to flow from the reservoir. Examples of typical viscosity ranges are shown in Table 2.4.

The significance of viscosity as an indicator of potential recovery is that the production rate is inversely proportional to the viscosity of the crude oil. Assuming an average sized reservoir, and with all other reservoir parameters being equal, the production rate of a given well would vary approximately as shown in Table 2.5.

The variation in production rate illustrates the impact of variations in reservoir oil viscosity. Ultimate recovery of oil is therefore very dependent upon the viscosity of the reservoir oil.

TABLE 2.4

OIL VISCOSITY CLASSIFICATIONS

| | Reservoir Viscosity of Oils |
|---|---|
| | Unit - Centipoise |
| Very Light | less than 1.0 |
| Light | 1 to 10 |
| Medium | 10 to 100 |
| Heavy | 50 to 1000 |
| Very Heavy | over 10,000 |

SOURCE: Canadian Energy Research Institute

TABLE 2.5

AVERAGE PRODUCTION RATES

| | Production Rate | |
|---|---|---|
| | Metric (metres/day) | American (barrels/day) |
| Very Light | over 50 | over 315 |
| Light | 50 to 100 | 315 to 630 |
| Medium | 5 to 50 | 32 to 315 |
| Heavy | 0.5 to 5 | 3.2 to 32 |
| Very Heavy | ----------Heat Injection Required---------- | |

SOURCE: Canadian Energy Research Institute

A further significant characteristic affecting the recovery of reservoir oil is the amount of dissolved gas in the oil. Oil in the reservoir is much like soda water in the bottle. Soda water fizzes and flows from the bottle because carbon dioxide is dissolved in the water and provides energy to lift the liquid from the bottle when the cap is removed and the pressure is released. Dissolved gas similarly comes out of the oil solution in the reservoir when a wellbore is opened to release pressure as the well is placed on production. Heavy oils hold less gas in solution than light oils and as a rule heavy oils show lower natural recovery than light oils.

Once the reservoir engineer obtains an impression of the reservoir oil characteristics, he can proceed to evaluate the controlling reservoir rock parameters which determine ultimate oil recovery. Depending on the properties of the oil in place, the following natural oil recovery mechanisms are often referred to:

(1) Solution Gas Drive - As oil is removed from the reservoir, gas dissolved in the oil is released by the drop in pressure and fills the vacated pore space.

(2) Fluid Expansion - Oil expands and moves toward the wellbore, as pressure is released by the wellbore production.

(3) Gravity Segregation - A natural gas cap and/or gas saturation exists, or dissolved gas segregates and collects in upper parts of the reservoir while oil drains to the bottom of the reservoir. Natural drainage of the oil to the bottom of the reservoir forces the oil to further collect into the wellbore.

(4) Natural Water Drive - Occassionally a water aquifer is found to underlie the reservoir, particularly in structural trap reservoirs. There are two ways in which the water may push the oil from the reservoir: the water may be connected to a major underground energy supply source, or the natural expansion of the water may move the oil.

(5) Natural Gas Cap Drive - Many reservoirs are found to be partially filled with oil and partially filled with free gas that has segregated from the oil over geologic time. Gas is much more compressible (spongy) than oil and depletes relatively slowly in response to oil production. The natural characteristics of gas extend the drive energy of the oil and further contribute to an ongoing gravity segregation.

The highest oil recovery reservoirs exhibit a combination of a natural gas cap drive and bottom water drive in a reservoir filled with light oil that is high in solution gas content. Most of the Alberta reef reservoirs exhibit this combination of recovery mechanisms. Typical oil recovery from Alberta reefs exceeds 50 percent of oil-in-place under these natural drive mechanisms.

In addition to natural reservoir drive energy, engineers and geologists have found that man-made energy can be forced into the reservoir to drive oil from the reservoir. Common fresh or salt water can be pumped at high pressure into strategically located injection wells to drive the oil towards oil producing wells. Water is the lowest-cost injection fluid. If a surplus of natural gas is available, then gas injection can be initiated instead of, and/or in conjunction with, water injection.

As a general rule, providing that the estimated recovery by primary methods does not exceed 50 percent, water injection will double and sometimes triple the ultimate recovery by natural drive mechanisms. If the natural primary depletion indicates a recovery of 10 percent, then secondary recovery by waterflood would increase the recovery to 20 percent and possibly 30 percent of original oil-in-place. Gas injection without water would probably increase the recovery to 15 percent and possibly 20 percent of original oil-in-place.

In order to estimate hydrocarbon reserves using the volumetric basis, the presumption is that geologists and engineers can determine the size of a reservoir on the basis of a few wells up to 1 mile apart in distance. Until some production history amounting to several years is available there is no other basis for calculating reserves.

### 2.2.3 Material Balance and Production History Techniques

Once some production history is available, the engineer can apply production decline curve methods and/or material balance methods to more accurately estimate recoverable reserves.

The production decline curve methodology involves recording the actual production rates and approximating the likely decline in production rates using a mathematical approximation. The hyperbolic type of production decline curve is the most mathematically consistent decline in relation to reservoir fluid flow principles. It is also the most

mathematically complex and difficult to apply. A harmonic decline is a simplistic and unique version of the general hyperbolic decline. Conceptually, the hyperbolic decline approach states that the rate of decline in the production rate is dependent upon the amount of production taken from the reservoir relative to the original oil-in-place. Hyperbolic rate of decline is therefore a function of recovery at a given point in time.

To reduce the complexity of calculation and simplify the approach to declines, a good approximation is achieved by employing exponential decline analysis. According to exponential decline theory, the percentage rate of decline remains constant throughout time and is independent of percent recovery at any given point in time. Exponential decline is sometimes referred to as the "constant percentage decline method."

An engineer's approach is to fit a decline curve to the production history and extrapolate the best fit into the future until the decline reaches the lower economic limit. Economic limit is determined when the cost to operate the well becomes larger than or equal to the revenue from production. Having determined the production rate for all points in time of the life of the well(s) it is a simple matter to add up the production and determine the recoverable reserves. Extrapolation for periods of time exceeding twice the production history tends to be dangerous and inaccurate. Once sufficient production history is accummulated a decline analysis can be conducted which allows the engineer to test his previous volumetric estimates of reserves. This test can be used to adjust previous estimates which were based on a volumetric analysis. Production decline methods of establishing reserves are extremely risky when used without consideration of volumetric reserve calculations. A volumetric reserve calculation can be used to establish the upper limit for recoverable reserves unless material balance calculations and production history together indicate that the volumetric reserve is too low.

Calculating material balance for oil reservoirs is analogous to analysing gas reservoirs according to the gas laws. An accounting is taken of all fluids extracted from the reservoir as well as all fluids returned/injected to the reservoir. Comparison of the balance of fluid withdrawals from the reservoir with corresponding changes in the measured reservoir pressure establishes a pressure depletion trend which can then be extrapolated to ultimate pressure depletion. 'Ultimate pressure depletion' is that pressure at which the production

rate dependent upon reservoir pressure declines to below the economic limit. Based on the material balance calculations and extrapolation, the total oil withdrawals to the point of ultimate pressure depletion represent the recoverable oil reserve.

## 2.3 Summary

The geologist's main function is to direct the exploration and locate drill sites to find a reservoir with hydrocarbon deposits. Once a hydrocarbon-bearing reservoir is found, the geologist and engineer work together to estimate the volumetric size of the reservoir. The engineer will also direct and plan the development of the reservoir and deliver the products to market. With respect to the economics of the activity, the engineer will attempt to forecast the production schedule based on available reserves information and production history. Production schedules need to be updated regularly as new production history information becomes available. Once established, engineers and economists are able to apply economic parameters to the production schedule and evaluate the volume of established reserves.

# Chapter 3

# RESERVES ESTIMATION TECHNIQUES AND DEFINITIONS

## 3.1 Advances in Estimation Techniques

Over the past twenty-five years there have been many developments in geology and petroleum engineering. The general level of knowledge of oil and gas production has increased and a better understanding of the geological characteristics of Alberta has been accumulated. This increase in knowledge has enabled engineers to produce more oil and gas from the same reservoirs and has helped explorationists find oil and gas more efficiently.

This knowledge has also helped geologists and engineers to more accurately assess reservoirs. More information about similar reservoirs helps the scientist in predicting the probable characteristics of new reservoirs. Production history from similar reservoirs also helps the scientist predict the probable production trends. In this way, the level of accuracy of reserves estimates improves as more is known about Alberta and as the science/art of reserves estimation grows.

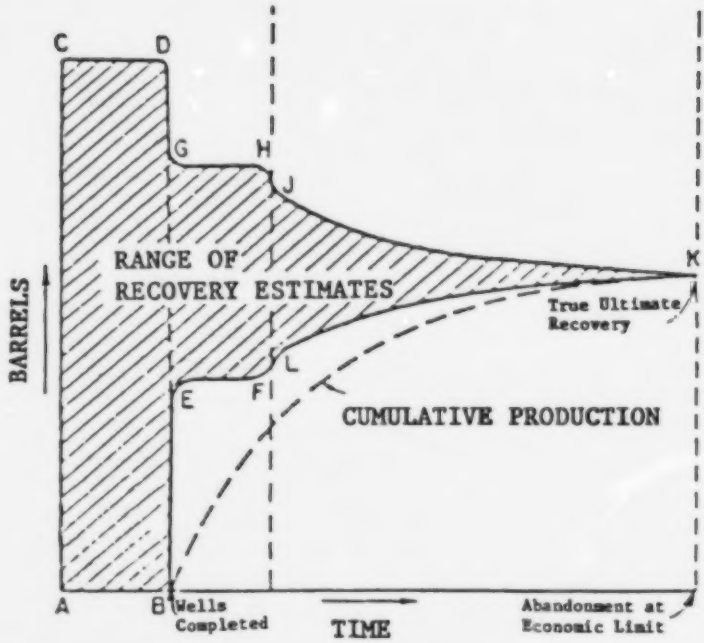
## 3.2 Improved Estimates as a Pool Matures

As a pool is discovered, completed, tested and produced, better information regarding the characteristics of that reservoir is accumulated. With better information, more accurate estimates of the recoverable reserves can be made.

The estimator is attempting to determine the exact number of cubic metres of oil or gas which will be recovered from a particular reservoir. With initial information the estimate may be quite far off. However, as the reservoir production process matures, more efficient methods of estimation can be undertaken. Figure 3.1 shows the general range of possible estimates at different stages of production.

FIGURE 3.1

ESTIMATES OF ESTABLISHED RESERVES




| PERIOD | I<br>BARRELS PER ACRE PERIOD | II<br>BARRELS PER ACRE-FOOT PERIOD | III<br>DECLINE CURVE PERIOD |
|---|---|---|---|
| TYPE OF DATA | COMPARATIVE DATA | VOLUMETRIC DATA | PERFORMANCE DATA |

SOURCE: J.J. Arps, Estimations of Primary Oil Reserves, Oil and Gas Property Evaluation and Reserve Estimates No. 3, AIME, 1970.

The range of estimates of existing recoverable reserves will converge over time as more information about the reservoir and production is accumulated.

## 3.3 Definitions of Oil and Gas Reserves

### 3.3.1 Basic Definitions

The introduction to this study made reference to statements made by the Honourable Joe Green, which were based on ultimate potential instead of proven or established reserves. This error was not unreasonable given the complexity of resource and reserves definitions. In order to understand the differences one must first define "resources." "Resources" refers to the total existence of hydrocarbons. Reserves are that portion of resources which are or will be economically recoverable. Ultimate Potential is divided into ultimate potential and established reserves. Established remaining reserves are reserves which we have already discovered. Remaining ultimate potential represent those reserves which are likely to be recovered in the future.

Ultimate Potential: This is an estimate of the initial established reserves which will have become developed in an area by the time all exploratory and development activity has ceased, having regard to the geological prospects of that area and anticipated technology and economic conditions. Ultimate potential includes cumulative production, remaining established reserves, and future additions through extensions of and revisions to existing pools and discovery of new pools.[1]

In his speech, the Honourable Joe Green referred to ultimate potential as available reserves. However, ultimate potential is a summation of all reserves which are likely to become available. The estimates of ultimate potential are very approximate. The most appropriate reference for the Minister would have been to quote from currently proven or established reserves.

There are several definitions which are used for the general category of discovered reserves. The current definition system used by the ERCB and CPA is based on established reserves. The other popular system for estimating reserves is called proven or proved reserves.

Proved Reserves (World Petroleum Congress-[WPC]): "The estimated quantities, at a specific date, which analysis of geological and engineering data demonstrates with reasonable certainty, to be recoverable in the future from known reservoirs under the economic and operational conditions of the same date."[2]

Established Reserves: "Those reserves recoverable under current technology and present and anticipated economic conditions, specifically proved by drilling, testing or production, plus that judgment portion of contiguous recoverable reserves that are interpreted to exist, from geological, geophysical or similar information, with reasonable certainty."[3]

Both of these definitions are used in the oil and gas industry in Canada. Generally, when preparing reports for the Securities and Exchange Commission, companies which are listed on major U.S. stock exhanges must use the SEC definition of proven reserves. For reports done only for Canadian Securities Commissions, the regulations permit a different definition of proven reserves which allows for a reasonable escalation of prices, given current expectations.

The definition of proven reserves as suggested by the Policy Statements to the Ontario Securities Commission (OSC) is as follows:

> Proven Reserves (Ontario Securities Commission-[OSC]): Those reserves estimated as recoverable under current technology and existing economic conditions, from that portion of a reservoir which can be reasonably evaluated as economically productive on the basis of analyses of drilling, geological, geophysical and engineering data, including the reserves to be obtained by enhanced recovery processes demonstrated to be economic and technically successful in the subject reservoir.
>
> Where reserves are clearly known to exist in a reservoir and would be physically recoverable but cannot be termed "proved reserves" because they are not commercially recoverable due to their remote location (i.e., frontier reserves) these reserves should be itemized separately in the report and their special circumstances should be fully explained.
>
> For forecasts of future net production, revenue, costs and net cash flow on a proved production, proved non-producing, and total proved reserve basis, and on an additional reserve basis, by jurisdiction (province, state,

> etc.), and in total, dollar values shall be calculated at current prices and costs, unless under contract as to price, to all future time. Additionally, dollar values may be presented based on forecast prices and costs but critical assumptions in such a forecast shall be stated. Net cash flow values shall be presented at discount rates of 0 percent, 10 percent, 15 percent and 20 percent.
>
> Also, probable additional reserves shall be reduced by an allowance for risk that is associated with the probability of obtaining production from such reserves.[4]

Each of the three different definitions (established, proven [WPC] and proven [OSC]) may generate a different volume of reserves and each is used under different circumstances.

### 3.3.2 Established Reserves

The definition of established reserves makes allowance for the incorporation of current technology advances and a reasonable forecast of economic conditions. This definition allows governments and regulatory agencies to make a "best estimate" of the reserves that are and will be available based on current knowledge and discoveries.

When established reserves are estimated for an entire province or country, individual well, pool or field, errors related to forecasts sometimes cancel out. The estimates of the expected total supply available from currently discovered resources arrived at by using this definition of established reserves are more suited to planning and regulatory purposes.

### 3.3.3 Proved Reserves (WPC)

The World Petroleum Congress has developed a definition of proved reserves which is essentially consistent with the U.S. Securities and Exchange Commission (SEC) definition. This definition is generally used for direct financial market disclosures. To value reserves is a very difficult task, given the lack of accurate technical and economic information. The SEC rule prohibiting technical and economic forecasts is designed to appraise reserves on an 'as is' basis and to avoid the large over- or under-valuations which can easily result from simple technological or economic assumptions or forecasts. Included in the SEC proviso is the caution that the estimate of proven reserves does not necessarily represent market value. The thrust of the SEC regulation is to provide some consistent method for companies

which are reporting to the investing public, to meet standard disclosure requirements.

Proven reserves are more sensitive to economic parameters than established reserves and they are used by the U.S. Securities and Exchange Commission (SEC) to regulate the reporting of public companies. The definition requires that reserves be estimated only using current economic conditions. This means that when the price of oil falls from $26 per barrel to $10 per barrel, reserves also fall. Even if one expects prices to rise in the future, thereby allowing more expensive reserves to be recovered, those expensive reserves will not be included in current proven reserves.

On the other hand, the definition of established reserves allows the volume of estimated reserves to be maintained if prices are reasonably expected to rise to a level where these reserves will be recovered in the future.

### 3.3.4 Proved Reserves (OSC)

The Ontario Securities Commission's definition of proved reserves allows for forecasts of prices etc., but, true to the principle of disclosure, all assumptions must be provided in such forecasts. The SEC's regulations are clearly an attempt to protect investors. The OSC's definition is intended to provide complete disclosure.

### 3.3.5 Which Definition to Use

Reserve estimates are used for several different purposes. When a banker loans money on the basis of reserves he requires an analysis of the ability of those reserves to service the loan. A conservative banker is wise to use a conservative definition of reserves in his decision-making process. The estimate of proved reserves based upon current prices as proposed by the SEC is usually quite conservative (assuming current prices do not fall).

The forecasting techniques and various discount factors suggested by the OSC pre-suppose that the reader of the reserves document is able to sift through the estimate and observe intelligently the implication of the assumptions on reserves, values and production rates. Although more information can be provided using such a format, it also requires a more sophisticated reader. For the purposes of

financial disclosure, either methodology is acceptable given the preference of the regulatory bodies. However, neither proved reserves (WPC) nor proved reserves (OSC) are appropriate for macro-economic planning decisions.

In order to obtain an estimate which meets the criterion of an economic planning tool, it must not only include an appraisal of the reserves available for bank credit, but also those reserves which are most likely to be available for national production and consumption. Therefore the definition of established reserves which considers present and anticipated economic conditions is a "best estimate" of the reserves which will actually be recoverable over time. The difference between established reserves and proven reserves could be minimal under specific conditions. However, the objective behind the estimate of established reserves is more consistent with the goals of macro-economic planning.

### 3.4 The Calculation of Remaining Established Reserves

In Alberta the "established reserves" definition is used by both the ERCB and CPA. Each year some of these reserves are produced, and some new reserves are added. The reserves left after production is deducted and new reserves are added are called remaining established reserves. Figure 3.2 shows the method used by the CPA to calculate remaining established reserves of crude oil for Canada.

Figure 3.2 contains revisions, extensions, discoveries and net production. Production is the amount produced by the country and is subtracted from remaining reserves from the previous year. Discoveries are estimates of reserves in new pools which have been found during the year. Extensions are new reserves found by development drilling around pools found in previous years. Revisions are adjustments made by the reserves estimators on estimates made previously which they consider require updating. Established reserves are only estimates and each year more information is acquired concerning each pool. As a result of this added information, new estimates of initial reserves are often made. Some adjustments result in an increase in reserves, some in a decrease.

Some years these revisions are so large relative to additions that they dominate the total additions number (see for example 1980 in Figure 3.2). In Alberta, negative revisions were large enough to

FIGURE 3.2

# CRUDE OIL
# HISTORICAL RECORD OF REMAINING ESTABLISHED RESERVES IN CANADA

Thousand Cubic Metres

| YEAR | Remaining at Beginning of Year (1) | GROSS ADDITIONS: Revisions — Negative (2) | Revisions — Positive (3) | Extensions (4) | Discoveries (5) | Total (6) | Net Production** (7) | Remaining at End of Year (8) | Net Change in Reserves during Year (9) |
|---|---|---|---|---|---|---|---|---|---|
| 1951* | 191 108 | | 13 208 | | 21 963 | 35 169 | 7 519 | 218 756 | 27 650 |
| 1952* | 218 756 | | 9 685 | | 48 064 | 57 749 | 9 614 | 266 891 | 48 135 |
| 1953* | 266 891 | | 24 143 | | 15 079 | 39 222 | 12 857 | 293 256 | 26 365 |
| 1954* | 293 256 | | 57 142 | | 15 608 | 72 750 | 15 194 | 350 812 | 57 556 |
| 1955* | 350 812 | | 58 139 | | 10 101 | 68 240 | 20 262 | 398 790 | 47 978 |
| 1956* | 398 790 | | 73 252 | | 7 658 | 80 910 | 26 907 | 452 793 | 54 003 |
| 1957* | 452 793 | | 26 540 | | 6 128 | 32 668 | 28 882 | 456 779 | 3 986 |
| 1958* | 456 779 | | 71 221 | | 1 490 | 72 701 | 26 346 | 503 094 | 46 315 |
| 1959* | 503 094 | | 66 918 | | 14 914 | 81 832 | 29 198 | 555 728 | 52 634 |
| 1960* | 555 728 | | 55 694 | | 3 503 | 59 197 | 30 368 | 584 557 | 28 829 |
| 1961* | 584 557 | | 110 788 | | 3 400 | 113 788 | 35 123 | 663 222 | 78 665 |
| 1962* | 663 222 | | 84 418 | | 3 282 | 87 720 | 38 914 | 712 028 | 48 806 |
| Break in Series | | | | | | | | | |
| 1963 | 1 062 733 | | | | | 13 944 | 40 758 | 1 035 919 | −26 814 |
| 1964 | 1 035 919 | | | | | 255 384 | 43 033 | 1 248 270 | 212 351 |
| 1965 | 1 248 270 | | | | | 196 556 | 46 337 | 1 398 489 | 150 219 |
| 1966 | 1 398 489 | | | | | 208 887 | 50 224 | 1 557 152 | 158 663 |
| 1967 | 1 557 152 | | | | | 124 587 | 54 690 | 1 627 049 | 69 897 |
| 1968 | 1 627 049 | | | | | 93 668 | 59 070 | 1 661 687 | 34 638 |
| 1969 | 1 661 687 | | | | | 66 646 | 62 516 | 1 665 807 | 4 120 |
| 1970 | 1 665 807 | | | | | 36 894 | 69 606 | 1 623 095 | −42 712 |
| 1971 | 1 623 095 | | | | | 77 676 | 76 297 | 1 584 434 | −38 661 |
| 1972 | 1 584 434 | | | | | 22 229 | 82 319 | 1 524 344 | −60 090 |
| 1973 | 1 524 344 | | | | | 6 577 | 99 423 | 1 431 458 | −92 886 |
| 1974 | 1 431 458 | | | | | −5 065 | 95 530 | 1 370 863 | −100 595 |
| 1975 | 1 370 863 | | | | | −6 380 | 79 897 | 1 244 686 | −86 177 |
| 1976 | 1 244 686 | | | | | 5 921 | 69 641 | 1 180 924 | −63 762 |
| 1977 | 1 180 924 | | | | | 10 227 | 70 872 | 1 120 279 | −60 645 |
| 1978 | 1 120 279 | 58 909 | 86 406 | 6 723 | 3 206 | 37 426 | 67 647 | 1 090 058 | −30 221 |
| 1979 | 1 090 058 | 25 200 | 57 660 | 33 874 | 5 081 | 71 415 | 79 469 | 1 082 004 | −8 054 |
| 1980 | 1 082 004 | 99 722 | 26 722 | 10 870 | 5 883 | −56 247 | 74 530 | 951 228 | −170 776 |
| 1981 | 951 228 | 45 219 | 208 396 | 11 129 | 5 914 | 178 220 | 66 471 | 1 063 575 | 112 347 |
| 1982 | 1 063 575 | 28 466 | 30 564 | 9 348 | 7 868 | 19 341 | 81 756 | 1 021 133 | −42 442 |
| 1983 | 1 021 133 | 30 986 | 73 334 | 19 184 | 4 542 | 66 074 | 64 488 | 1 022 719 | 1 585 |
| 1984 | 1 022 719 | | | | | [illegible] | 73 [illegible] | 949 033 | −73 [illegible] |
| 1985 | 949 033 | | | | | [illegible] | [illegible] | 915 [illegible] | [illegible] |

* Proved reserves

** Preliminary estimate

Note: East Coast Offshore reserves booked for first time in 1981
Arctic Islands reserves booked for first time in 1985.

SOURCE: Canadian Petroleum Association

*Proved Reserves

generate negative additions by the CPA in 1975 and 1980 and by the ERCB in 1976, despite the healthy drilling activity being recorded in those years.

### 3.5 Changes in Methodology

Figure 3.2 shows the calculations made by the CPA of reserve additions from 1951 to 1985. Until 1963 the CPA estimated proved reserves. From 1963 to 1977 an estimate was made of probable reserves which was comparable with the ERCB's proved category.

In 1978, the Canadian Oil Industry Task Force on Definitions recommended a standardized nationwide change to the definition of established reserves. As a result of the recommendations made by the taskforce, the CPA changed from probable and the ERCB changed their estimation base from proved reserves to established reserves in 1978. The task force published a list of current reserves terminology and a list of recommended methodology. Table 3.1 shows the list of reserves terminology which had previously been employed.

TABLE 3.1

FORMER DEFINITIONS USED TO ESTIMATE RESERVES

| Estimator | Pre - 1978 Reserve Term |
|---|---|
| British Columbia Ministry of Energy, Mines and Petroleum Resources | Established |
| Alberta Energy Resources Conservation Board | Proved |
| Saskatchewan Department of Mineral Resources | Proven Plus Probable |
| National Energy Board | Established |
| Canadian Petroleum Association | Probable |

SOURCE: Report of Joint Task Force on Uniform Reserves Terminology, November 1978.

As of November 1978, all these organizations shifted to the "established reserves"-based category. In Table 3.1, the ERCB is represented as having used the "proved reserves" definition; the CPA is represented as having used the "probable" definition, however, CPA

records identify proven and probable, therefore appropriate historical comparisons can be made between CPA and ERCB data.

The general consensus between the CPA and the ERCB seems to be that the actual methodology of reserve estimation was not changed upon the standardization of reserve definitions. Rather, the definition was adopted to better describe the process being employed at that time.

### 3.6 The Scope of Reserves Data in Alberta

The ERCB and CPA both supply reserves estimates for crude oil, marketable natural gas, natural gas liquids, non-conventional oil, non-conventional bitumen and sulphur. Both organizations also include information on natural gas liquids, dividing them into pentanes plus and liquified petroleum gases. Both organizations supply reserves estimates which date back to the early 1950s at least.

The CPA provides many different breakdowns of Canadian hydrocarbon reserves. Most categories are provided by province or territory/region. Many different reserves categories are classified by initial year of discovery or by geological age. The volume and scope of the data presentation make the reserves section of the CPA Statistical Handbook one of the most complete published sources of Canadian reserves data.

The ERCB has many publications containing reserves information. The most recent reserves information is summarized in the publication "Alberta's Reserves of Crude Oil, Oil Sands, Gas, Natural Gas Liquids, and Sulphur, at December 31, 1985."[5] This summary is published annually by the ERCB. The publication contains a disaggregated analysis of hydrocarbon reserves in Alberta and some historical time series data. This data is also available on computer tapes from the ERCB.

Both the CPA and ERCB keep historical records of previous data and previous reserves estimates. Therefore, even if some data does not appear to be available through the current publications, it can often be obtained through contacting the organizations. For example, the CPA publishes a breakdown of reserves classified by year of discovery and geological age. The ERCB continues to classify gas reserves using this method but does not classify oil this way. To obtain such data from the ERCB, one would have to have access to older publications. To

obtain a comprehensive version of such data would require additional work by the ERCB.

Both organizations are very cooperative and willing to supply data to interested parties.

There is one valuable data reserves series which is being discontinued by both organizations and may no longer be recoverable. "Revisions" have historically been reported as a separate category, within which increases and decreases were separately displayed. Now, neither organization will be publishing the revisions in reserves as a separate category, and will combine revisions with reserves additions to arrive at a net change in established reserves. The ERCB oil department has recently begun to record such information using the format outlined in Figure 3.3.

The format currently used by the ERCB disaggregates additions to reserves by new discoveries, development and re-evaluation, and enhanced recovery (see Figure 3.4).

The CPA, as of 1984, presents gross additions instead of the four categories referred to above. The absence of this additional categorization of reserves data will make it much more difficult to analyze the effects of development and exploration activity on reserves additions.

FIGURE 3.3

ERCB RECORDING FORMAT

| MONTH | | RIM PRIMARY | | | | | | RIM SECONDARY | | | | | | RIM TERTIARY | | | | | | RIM TOTAL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Gas | | Decline | | Recovery | | Gas | | Decline | | Recovery | | Gas | | Decline | | Recovery | | | |
| | | Month | Cum | Month | Cum | Month | Cum | Month | Cum | Month | Cum | Month | Cum | Month | Cum | Month | Cum | Month | Cum | Month | Cum |
| January | Lab | 2 190.3 | 2 190.3 | 432.8 | 432.8 | (71.6) | (71.6) | 48.5 | 48.5 | - | - | (211.0) | (211.0) | - | - | - | - | - | - | | |
| | MC | 139.6 | 139.6 | 281.7 | 281.7 | 216.7 | 216.7 | 270.0 | 270.0 | - | - | - | - | - | - | - | - | - | - | 2 307.3 | 2 307.3 |
| | Total | 2 307.9 | 2 307.9 | 714.5 | 714.5 | 145.1 | 145.1 | 318.5 | 318.5 | - | - | (211.0) | (211.0) | - | - | - | - | - | - | 997.1 | 997.1 |
| February | Lab | | | | | | | | | | | | | | | | | | | 3 214.7 | 3 214.7 |
| | MC | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | |
| March | Lab | | | | | | | | | | | | | | | | | | | | |
| | MC | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | |
| April | Lab | | | | | | | | | | | | | | | | | | | | |
| | MC | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | |
| May | Lab | | | | | | | | | | | | | | | | | | | | |
| | MC | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | |
| June | Lab | | | | | | | | | | | | | | | | | | | | |
| | MC | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | |
| July | Lab | | | | | | | | | | | | | | | | | | | | |
| | MC | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | |
| August | Lab | | | | | | | | | | | | | | | | | | | | |
| | MC | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | |
| Sept | Lab | | | | | | | | | | | | | | | | | | | | |
| | MC | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | |
| October | Lab | | | | | | | | | | | | | | | | | | | | |
| | MC | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | |
| November | Lab | | | | | | | | | | | | | | | | | | | | |
| | MC | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | |
| December | Lab | | | | | | | | | | | | | | | | | | | | |
| | MC | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | |

SOURCE: ERCB, Oil Department

FIGURE 3.4

ERCB

TABLE A-4 ADDITIONS TO ESTABLISHED RESERVES OF CONVENTIONAL CRUDE OIL 1951-1985
millions of cubic metres

| Year | 1 New Discoveries (Initial Year) | 2 Development and Re-evaluation | 3 Enhanced Recovery | 4 Total |
|---|---|---|---|---|
| 1951 | 15.3 | 29.2 | | 44.5 |
| 1952 | 14.0 | 48.5 | | 62.5 |
| 1953 | 24.2 | 42.4 | | 66.6 |
| 1954 | 1.9 | 53.7 | | 55.6 |
| 1955 | 9.4 | 58.8 | | 68.2 |
| 1956 | 3.5 | 78.5 | | 82.0 |
| 1957 | 10.8 | 29.1 | | 39.9 |
| 1958 | 1.3 | −4.8 | 4.9 | 1.4 |
| 1959 | 14.3 | 37.2 | 16.0 | 67.5 |
| 1960 | 0.5 | 29.9 | 18.1 | 48.6 |
| 1961 | 1.7 | 31.5 | 24.5 | 57.5 |
| 1962 | 2.9 | 21.8 | 19.9 | 44.0 |
| 1963 | 14.6 | 12.6 | 29.2 | 56.6 |
| 1964 | 9.5 | 88.2 | 250.8 | 348.5 |
| 1965 | 28.6 | 42.6 | −2.4 | 68.8 |
| 1966 | 89.1 | 13.5 | 38.3 | 140.8 |
| 1967 | 57.2 | 15.7 | 22.2 | 95.2 |
| 1968 | 62.0 | 14.8 | 42.9 | 119.8 |
| 1969 | 40.5 | −44.5 | 58.5 | 54.5 |
| 1970 | 8.4 | −7.6 | 36.1 | 36.7 |
| 1971 | 14.0 | 8.7 | −0.8 | 22.1 |
| 1972 | 10.8 | −5.6 | 14.8 | 20.0 |
| 1973 | 5.1 | −6.0 | 10.2 | 9.2 |
| 1974 | 4.3 | 3.3 | 30.8 | 38.5 |
| 1975 | 1.6 | 2.1 | 3.3 | 7.0 |
| 1976 | 2.5 | 5.9 | −27.0 | −18.6 |
| 1977 | 4.8 | 5.1 | 9.2 | 19.1 |
| 1978 | 24.9 | −1.9 | 1.4 | 24.4 |
| 1979 | 19.2 | 10.3 | 4.8 | 34.3 |
| 1980 | 9.0 | 5.1 | 8.6 | 22.7 |
| 1981 | 15.0 | 7.2 | 10.4 | 32.6 |
| 1982 | 16.8 | −16.5 | 6.6 | 6.9 |
| 1983 | 21.4 | 24.8 | 17.9 | 64.1 |
| 1984 | 29.1 | −12.0 | 24.1 | 41.2 |
| 1985 | 32.7 | 11.2 | 20.2 | 64.0* |

* Discrepancies are due to rounding.

SOURCE: ERCB Publication 86-18

**Footnotes**

[1]CPA Statistical Handbook.

[2]Study Group Report, Classification and Nomenclature Systems for Petroleum and Petroleum Reserves, World Petroleum Congress, John Wiley and Sons Ltd., New York, New York, 1984.

[3]Report of Joint Task Force on Uniform Reserves Terminology, November 1978 (Membership: B.C., Alberta, ERCB, Saskatchewan, NEB, IPAC, CPA).

[4]Ontario Securities Commission Policy Statements National Policy No. 2-B, Guide for Engineers and Geologists Submitting Oil and Gas Reports to Canadian Provincial Securities Administrators, 1985.

[5]ERCB Series ST-18. The ERCB publishes a complete listing of natural gas reserves under Series ST-35.

# Chapter 4

## THE ERCB METHODOLOGY

The ERCB follows a specific procedure in estimating oil and gas reserves. This procedure is based upon information which is obtained from the operators of the oil and gas wells and pools being evaluated. The ERCB has departments specializing in oil, oil sands, and gas, and it has a separate geology department. Each of these departments has a specific role to play in reserves estimations.

### 4.1 Oil Reserves

#### 4.1.1 Prorationing

In 1964, the prorationing scheme for the sale of crude oil in Alberta was changed to a reserves-based system, under which the established reserves minus one-half the cumulative production (proratable reserves) for each producing oil pool would determine the pool's prorated share. The larger the proratable reserves, the larger the production share allowed under the prorationing program. Thus, starting in 1964, the estimates of reserves booked by the ERCB became very important to the economics of oil producers. Over the latter half of the 1960s, there were many discussions and hearings regarding the oil reserves "booked" for specific pools in Alberta. This concentrated interest in reserves may have had some effect upon reserves booked by the ERCB.

Oil, unlike gas, has a low recovery rate relative to the total oil-in-place. Over time, the level of oil recovery will tend to rise as new technologies and knowledge are applied to the reservoir. Therefore, the more study that is done on these reservoirs, the higher the estimated recovery rates are likely to be.

The prorationing system prorates production on the basis of a pool's proratable reserves relative to other pools. When the system was introduced, it led to competition between some major companies to obtain higher reserves estimates on pools in which they had a higher interest and lower reserves estimates on pools in which their interest was low or nonexistent. This may have introduced an upward bias to the

general level of reserves estimations as well. As a regulatory body, the ERCB was empowered to employ the most qualified technical personnel available. If we compare the level of ERCB established oil reserves to those estimated by the CPA, we see that the ERCB estimates have in fact been consistently lower. Therefore, it appears to be the case that, based upon a scientific approach, the ERCB was successful in resisting pressures to raise its estimates above what was most accurate for the times.

### 4.1.2 Estimation Procedure

After a well licence has been obtained and the well is completed, the operator is required to file a "Form O-38" with the ERCB. (See Figure 4.1) This form includes the information required to make an initial estimate of reserves. Additional information is obtained by the ERCB from the operator by request.

The geology department of the ERCB reviews this information first and advises the oil department concerning the likely characteristics of the reservoir. The oil department then uses this information to evaluate the established reserves. These departments follow the standard scientific approaches outlined in Chapter 2.

Within the ERCB, the levels of authority which are required to decide the official reserves estimate are determined by the size of the pool. Small pools can be appraised by a senior supervisor, large pools generally require management level input, and very large pools may be brought in front of the Board for a decision.

If the company or companies concerned do not agree with the estimate, the decision may be appealed and new information or performance data which would suggest a re-evaluation may be presented. If there are further objections, the company or companies involved can request a hearing in front of the Board in which a final determination of reserves will be made.

### 4.1.3 Periodic Reviews

In addition to the initial reserves estimate, the oil department undertakes periodic reviews of specific oil pools. Reviews are undertaken in cases where there are applications for enhanced recovery and concurrent production, etc. The oil department meets monthly to

FIGURE 4.1

ERCB FORM O - 38

ERCB Energy Resources Conservation Board 640 Fifth Avenue SW Calgary, Alberta T2P 3G4

## Application for a New Well Base Allowable or Base MRL

Confidential Pools and Undefined Areas only. Please complete form in triplicate. For Conditions see over.

Well Name _____ Unique Well Identifier S | LE | LS | SC | TWP | RG | W | M | E | S

Field _____ Pool _____ Formation _____

K.B. Elevation _____ m Finished Drilling Date: Y M D On Production Date: Y M D

| Initial Production Data | Date Y | M | D | Hours | Production Method | Choke / Strokes | Clean Oil Production | GOR | Water Cut $f_w$ | Oil Density kg/m³ |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

FOR BOARD USE ONLY

| | OPERATOR'S SUBMISSION | BOARD STAFF | PROPOSAL | BOARD DECISION |
|---|---|---|---|---|
| G/O interface ☐ or Porosity Top ☐ m(KB) | | | | |
| O/W interface ☐ or Porosity Base ☐ m(KB) | | | | |
| Cored Interval m(KB) | | | | |
| Perforated Interval m | | | | |
| Cut-Offs Ø Upper / Lower % | | | | |
| K Upper / Lower mD | | | | |
| Assigned Area ha | | | | |
| H, h m | | | | |
| Ø fraction | | | | |
| 1-Sw fraction | | | | |
| 1/Boi fraction | | | | |
| N $10^3 m^3$ | | | | |
| Ri fraction | | | | |
| Ri N (U) $10^3 m^3$ | | | | |
| Average Well Depth m | | | | |
| $P_b$ kPa | | | | |
| Rsi $m^3/m^3$ | | | | |

Estimated Reservoir Pressure (Gauge) kPa _____ and Temperature _____ °C @ _____ m(KB).

Submit with the application any necessary supporting evidence of source of data including the perforated and completion intervals.

Date Board Form S-4 submitted: Y M D

(S-4 must be submitted within 14 days of commencement of regular production (Section 12.020 (2) Oil & Gas Conservation Regulations.)

Unique Well Identifier S | LE | LS | SC | TWP | RG | W | M | E | S

Base Allowable or Base MRL Data (conditions prescribed on reverse)

☐ Light-and-Medium-Density Crude Oil

☐ Heavy-Density Crude Oil

BWR _____ $m^3/d$ Base MRL _____ $m^3/d$

Base GOR _____ WDI Base _____

Np @ _____ = _____ $m^3$ U - P/2 _____ $10^3 m^3$

Pool Designation _____

Date _____ Signed by _____

Company _____

FOR BOARD USE ONLY

Remarks: _____

per _____

Energy Resources Conservation Board

Date Approved: Y M D

0 38 84 01

consider changes in reserves estimations and to add new pools. In addition, the ERCB conducts an annual review of all the oil pools and publishes the results, by pool, in the reserves publications (see Appendix C).

If a company feels that the reserves which the ERCB has assigned to its pool are not appropriate, it can request a review. During such a review the company should supply additional technical information to support its claim. The oil department will then conduct a review of that pool. If the company is not satisfied with the result, a reserves hearing can be requested.

In 1964, when the prorationing system was transferred to a reserves-based calculation, the estimation of reserves became a more contentious issue. More hearings were held to establish the reserves of major pools and many adjustments in reserves were recorded.

The general approach to reserves booking by the ERCB can be characterized as a careful one. Because of the policy implications of these estimates, the estimation procedures must be followed properly. However careful the estimate is, new information is acquired each year about each pool and this information often indicates that previous estimates were either too high or too low. The oil department of the ERCB, through its regular updating and review procedures, maintains up-to-date records on the thousands of wells in Alberta and, therefore, is in the best possible position to be able to accurately estimate the established oil reserves in Alberta.

#### 4.1.4 Maximum Rate Limitations

The ERCB also establishes a maximum rate limitation based upon reserves. However, maximum rate limitations can also be established based upon what are referred to as technical factors. These technical factors are presented by the operator to show that higher rates of production will not create reservoir damage, thereby supporting a case for higher allowable production rates for a given pool.

The prorationing system also contains a floor production level (Basic Well Rate) based upon economic criteria, below which an operator will not be required to produce. If the normal proration production allocation is below the Basic Well Rate (BWR), the basic well rate becomes the allowable rate of oil production. If the Maximum Rate

Limitation is equal to or greater than the BWR, then it becomes the upper limit of the allowable rate of oil production.

If the operator feels that the estimate of reserves is too low, he may appeal the estimate and ask to have it raised to increase the Maximum Rate Limitation (MRL) or prorated share of the market demand.

## 4.2 Gas Reserves

### 4.2.1 Estimation Methodology

There is no ERCB prorationing system in Alberta for natural gas. Reserves are estimated using the techniques described in Chapter 2. Again, the ERCB geology department provides an analysis of the reservoir, based upon data received from the operator, to the engineering personnel in the ERCB gas department.

The reserves are then estimated and reviewed by the gas reserves group which prepares reserves estimates of gas pools in Alberta. Special study pools are referred to the Reservoir Review Committee, comprised of representatives of the gas department and the geology department. This committee meets on an ad hoc basis. Additional updates to reserves estimates are made periodically when additional information on particular pools is received. The gas department has developed a program for reviewing the most significant reserves in the province on a routine basis.

Companies can request a hearing if they disagree with the estimates which are made by the gas department of the Board. However, these estimates are much less contentious than are estimates for oil reserves, because they do not form the basis of a prorationing system. The major decision in which gas reserves estimates are utilized involves the determination of surplus gas for export. In applications for gas removal, such reserves estimates can become quite important.

### 4.2.2 Gas Reserves Estimates Over Time

During 1973, marketable gas reserves for Alberta were re-estimated using new economic assumptions. Because of the significant price increases during that period, a major study of gas reserves was undertaken. The results of this study indicated that 85 billion cubic metres of established marketable gas reserves should be added to the reserves base as a result of higher recovery factors due to higher

prices or better economics. Other reviews occurred in 1974, 1976, 1978, 1981 and 1984, resulting in major adjustments.[1]

Appendix D to this study includes important charts and figures from a report by the ERCB entitled "Alberta Gas Reserve Trends, 31 December, 1985." In this report the gas department of the ERCB assigns reserves back to the original year of discovery and calculates appreciation factors. This process allows the department to observe how additional reserves were added after a gas discovery was made. This methodology allows an estimate to be made of possible reserves which may be available in the future from existing reserves.

Gas reserves are ultimately tabulated using a similar methodology to that used for oil reserves. Presently, reserves are broken down into two major categories: new discoveries, and development and re-evaluation. Additions to established reserves of marketable gas, as published by the ERCB, are shown in Figure 4.2. The adjustments mentioned above are included in the column labelled Development and Re-evaluation.

Figure 4.3 provides a matrix of estimates of gas reserves over 300 million cubic metres in size and their appreciation over time. The discovery year zero (0) represents the reserves assigned to wells discovered during that year, at the end of that same year. Year 1 represents the estimate of reserves discovered in that year, at the end of the second year. Thus, at the end of 1974, reserves discovered in 1954 had grown from 13,021 million cubic metres to 137,104 million cubic metres. Reserves appreciation results from development drilling, higher recovery factors, better recovery over time due to better economic conditions, or other adjustments to the original reserves.

FIGURE 4.2

ERCB

TABLE A-5 ADDITIONS TO ESTABLISHED RESERVES OF MARKETABLE GAS
1951-1985
billions of cubic metres

| Year | 1<br>New Discoveries<br>(Initial Year) | 2<br>Development and<br>Re-evaluation | 3<br>Total |
|---|---|---|---|
| 1951 | 6.2 | 55.0 | 61.2 |
| 1952 | • | • | 87.8 |
| 1953 | • | • | 76.1 |
| 1954 | • | • | 58.8 |
| 1955 | • | • | 59.3 |
| 1956 | • | • | 64.5 |
| 1957 | • | • | 64.9 |
| 1958 | • | • | 110.4 |
| 1959 | • | • | 88.5 |
| 1960 | 18.2 | 101.7 | 119.9 |
| 1961 | 9.6 | 3.7 | 13.3 |
| 1962 | 8.7 | 41.0 | 49.7 |
| 1963 | 3.1 | 32.7 | 35.8 |
| 1964 | 7.2 | 78.7 | 85.9 |
| 1965 | 11.3 | 78.4 | 89.7 |
| 1966 | 2.1 | 38.6 | 40.7 |
| 1967 | 24.3 | 49.6 | 73.9 |
| 1968 | 15.3 | 119.3 | 134.6 |
| 1969 | 18.6 | 68.9 | 87.5 |
| 1970 | 7.6 | 38.7 | 46.2 |
| 1971 | 4.8 | 40.6 | 45.4 |
| 1972 | 12.5 | 32.8 | 45.2 |
| 1973 | 7.8 | 175.6 | 183.4 |
| 1974 | 8.6 | 138.4 | 147.0 |
| 1975 | 0.8 | 20.0 | 20.8 |
| 1976 | 6.9 | 98.7 | 105.6 |
| 1977 | 6.6 | 120.9 | 127.6 |
| 1978 | 24.4 | 138.9 | 163.3 |
| 1979 | 16.4 | 106.8 | 123.2 |
| 1980 | 30.0 | 62.5 | 92.4• |
| 1981 | 28.9 | 88.1 | 117.0 |
| 1982 | 10.6 | 108.1 | 118.7 |
| 1983 | 16.3 | 22.7 | 39.0 |
| 1984 | 9.6 | 30.9 | 40.5 |
| 1985 | 11.5 | 31.1 | 42.6 |

• Discrepancies are due to rounding.
• Not available.

SOURCE: ERCB 86-18

# FIGURE 4.3

## ERCB Table G-3

TABLE G-3 HISTORICAL SUMMARY OF APPRECIATION OF INITIAL ESTABLISHED RESERVES OF MARKETABLE GAS
As at 31 December 1985
YEARS FROM END OF DISCOVERY YEAR
INITIAL RESERVES OF MARKETABLE GAS
MILLIONS OF CUBIC METRES

| Discovery Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 10 144 | 26 468 | 47 138 | 65 089 | 33 986 | 47 510 | 48 770 | 48 006 | 48 052 | 48 053 | 53 977 | 53 329 | 52 638 | 53 635 | 57 178 | 58 358 | 57 793 | 55 885 | 56 393 | 57 234 | 54 769 |
| 1952 | 13 565 | 21 192 | 27 899 | 29 183 | 35 347 | 40 059 | 46 463 | 47 083 | 47 629 | 51 503 | 55 843 | 59 514 | 62 289 | 65 442 | 63 367 | 66 334 | 68 502 | 69 759 | 69 759 | 69 541 | 70 954 |
| 1953 | 27 873 | 54 845 | 61 980 | 53 087 | 53 884 | 49 303 | 54 003 | 59 492 | 68 860 | 72 847 | 74 222 | 78 735 | 84 239 | 80 197 | 80 660 | 80 180 | 80 690 | 81 426 | 75 237 | 74 813 | 77 268 |
| 1954 | 12 880 | 24 228 | 61 563 | 67 384 | 99 221 | 111 500 | 130 616 | 126 932 | 133 711 | 133 289 | 136 459 | 137 514 | 136 465 | 137 157 | 137 890 | 134 465 | 125 117 | 126 554 | 128 356 | 126 914 | 126 372 |
| 1955 | 6 371 | 10 968 | 22 040 | 26 971 | 26 796 | 28 290 | 33 614 | 36 082 | 36 701 | 37 486 | 38 378 | 41 791 | 41 393 | 43 900 | 44 498 | 46 090 | 47 944 | 50 154 | 55 156 | 56 139 | 55 265 |
| 1956 | 11 853 | 16 396 | 22 510 | 23 830 | 38 606 | 41 538 | 46 026 | 48 039 | 54 158 | 58 096 | 56 825 | 58 401 | 60 034 | 61 026 | 61 311 | 64 656 | 65 026 | 69 883 | 70 531 | 67 432 | 68 111 |
| 1957 | 34 045 | 52 896 | 70 260 | 86 811 | 90 053 | 92 365 | 79 537 | 78 475 | 75 236 | 78 538 | 79 773 | 77 983 | 69 129 | 70 617 | 79 740 | 82 644 | 92 309 | 95 448 | 94 780 | 94 814 | 94 780 |
| 1958 | 37 558 | 53 084 | 62 875 | 61 550 | 70 265 | 69 963 | 69 546 | 66 328 | 66 537 | 68 562 | 68 895 | 72 725 | 72 278 | 73 545 | 78 752 | 77 279 | 77 862 | 75 310 | 76 741 | 77 855 | 78 358 |
| 1959 | 16 675 | 40 671 | 45 698 | 48 071 | 47 762 | 69 484 | 98 631 | 98 377 | 106 389 | 106 237 | 106 542 | 110 484 | 112 005 | 110 941 | 123 093 | 128 853 | 133 209 | 137 808 | 140 811 | 133 495 | 140 299 |
| 1960 | 17 831 | 32 644 | 23 683 | 26 775 | 30 877 | 38 037 | 44 736 | 46 227 | 46 950 | 46 840 | 46 674 | 43 579 | 41 468 | 42 812 | 43 121 | 38 849 | 39 113 | 40 242 | 40 733 | 40 425 | 41 199 |
| 1961 | 10 412 | 17 699 | 23 540 | 33 003 | 56 765 | 62 317 | 67 859 | 120 231 | 135 416 | 139 875 | 141 378 | 144 299 | 155 960 | 158 126 | 146 635 | 147 485 | 147 112 | 130 520 | 132 303 | 123 179 | 126 243 |
| 1962 | 9 338 | 31 985 | 44 646 | 45 330 | 53 990 | 59 327 | 59 300 | 60 706 | 61 746 | 63 477 | 63 987 | 64 619 | 64 682 | 61 821 | 60 805 | 60 936 | 61 586 | 61 933 | 61 395 | 56 462 | 57 163 |
| 1963 | 6 567 | 7 721 | 9 906 | 15 193 | 21 981 | 20 881 | 23 303 | 27 503 | 45 861 | 47 727 | 53 380 | 53 067 | 53 296 | 55 206 | 55 703 | 55 335 | 58 407 | 59 295 | 59 544 | 64 425 | 64 290 |
| 1964 | 3 497 | 17 737 | 16 586 | 13 230 | 13 357 | 13 526 | 13 868 | 12 206 | 12 038 | 16 970 | 16 826 | 14 640 | 15 122 | 17 097 | 18 611 | 18 111 | 18 845 | 19 018 | 19 312 | 20 063 | 20 217 |
| 1965 | 10 427 | 19 496 | 19 479 | 23 059 | 31 015 | 31 276 | 31 030 | 30 043 | 30 427 | 31 370 | 32 288 | 32 979 | 36 623 | 39 772 | 43 221 | 44 708 | 46 315 | 48 723 | 48 571 | 51 636 | 52 594 |
| 1966 | 6 142 | 6 292 | 5 245 | 5 640 | 6 090 | 6 315 | 6 371 | 6 285 | 6 803 | 6 126 | 6 879 | 7 782 | 8 556 | 8 977 | 9 942 | 12 285 | 11 997 | 12 244 | 12 623 | 12 565 | |
| 1967 | 8 819 | 38 053 | 59 606 | 69 275 | 72 413 | 57 839 | 56 343 | 57 446 | 60 790 | 61 606 | 62 943 | 64 704 | 66 452 | 67 610 | 67 283 | 73 671 | 69 470 | 66 986 | 67 311 | | |
| 1968 | 7 993 | 9 232 | 12 349 | 12 840 | 15 348 | 17 530 | 18 577 | 17 475 | 18 069 | 18 280 | 24 533 | 26 581 | 26 900 | 26 572 | 25 811 | 25 641 | 25 906 | 25 216 | | | |
| 1969 | 19 085 | 42 431 | 45 750 | 45 808 | 50 584 | 51 229 | 45 255 | 46 089 | 48 416 | 51 024 | 50 960 | 50 941 | 51 051 | 52 713 | 52 600 | 51 279 | 51 910 | | | | |
| 1970 | 2 662 | 3 131 | 3 233 | 4 049 | 4 992 | 6 131 | 7 201 | 8 593 | 10 908 | 14 606 | 13 174 | 14 558 | 15 352 | 16 315 | 18 816 | 18 560 | | | | | |
| 1971 | 5 224 | 5 973 | 6 337 | 6 531 | 9 001 | 13 004 | 17 864 | 18 490 | 18 856 | 19 367 | 20 708 | 21 237 | 21 708 | 21 886 | 22 302 | | | | | | |
| 1972 | 10 395 | 10 622 | 13 571 | 18 430 | 46 925 | 51 579 | 55 148 | 59 537 | 51 035 | 52 701 | 53 295 | 61 823 | 58 370 | 56 945 | | | | | | | |
| 1973 | 12 702 | 18 384 | 20 394 | 23 817 | 27 675 | 31 983 | 35 327 | 36 608 | 38 184 | 40 871 | 41 313 | 41 346 | 42 657 | | | | | | | | |
| 1974 | 10 748 | 11 435 | 19 975 | 29 037 | 35 914 | 39 252 | 43 649 | 42 330 | 43 924 | 47 033 | 48 636 | 51 338 | | | | | | | | | |
| 1975 | 378 | 8 035 | 8 475 | 13 709 | 13 872 | 13 790 | 14 132 | 17 653 | 18 044 | 18 875 | 19 990 | | | | | | | | | | |
| 1976 | 5 572 | 15 951 | 26 498 | 33 442 | 35 823 | 38 436 | 45 368 | 46 784 | 45 253 | 45 935 | | | | | | | | | | | |
| 1977 | 4 987 | 36 284 | 44 226 | 49 189 | 53 216 | 53 446 | 53 733 | 57 242 | 59 145 | | | | | | | | | | | | |
| 1978 | 2 662 | 12 820 | 14 217 | 21 679 | 26 520 | 29 788 | 34 324 | 40 421 | | | | | | | | | | | | | |
| 1979 | 330 | 9 759 | 15 387 | 27 141 | 27 837 | 28 495 | 28 484 | | | | | | | | | | | | | | |
| 1980 | 2 494 | 5 921 | 9 976 | 13 044 | 15 383 | 30 941 | | | | | | | | | | | | | | | |
| 1981 | 2 044 | 6 485 | 9 189 | 10 757 | 11 632 | | | | | | | | | | | | | | | | |
| 1982 | 652 | 652 | 1 704 | 2 634 | | | | | | | | | | | | | | | | | |
| 1983 | 348 | 933 | 2 941 | | | | | | | | | | | | | | | | | | |
| 1984 | 0 | 2 009 | | | | | | | | | | | | | | | | | | | |
| 1985 | 394 | | | | | | | | | | | | | | | | | | | | |
| CUMULATIVE RATIO | 1.000 | 1.962 | 2.664 | 3.043 | 3.526 | 3.794 | 4.090 | 4.348 | 4.574 | 4.734 | 4.857 | 4.993 | 5.063 | 5.114 | 5.216 | 5.284 | 5.332 | 5.327 | 5.364 | 5.357 | 5.390 |

SOURCE: Alberta Gas Reserve Trends, 31 December 1985

**Footnotes**

[1]ERCB Alberta Gas Reserve Trends, December 31, 1984

# Chapter 5

## THE CPA METHODOLOGY

### 5.1 Estimation Methodology

The Canadian Petroleum Association (CPA) publishes yearly estimates of reserves not only for Alberta but also for all of Canada. The yearly numbers are broken down by province and major frontier region and usually extend back annually to the early 1950s.

The CPA, as an industry association, has many members who are either operators of or participants in most large pools found in the province of Alberta. This allows the CPA tremendous access to information as well as an intimate familiarity with most large pools. In order to make use of such information and expertise, the CPA reserves committee allocates each pool to a specific member of the committee. Assessments of pools which members of the committee neither operate nor participate in are allocated by region among the 16 committee members.

Each member provides an annual estimate to the committee of the established reserves from each assigned pool. The committee discusses these estimates and may accept, raise or lower them. The executive of this committee deals with the few cases in which no agreement can be reached among the committee members. The decision of the executive concerning estimates is final.

Unlike the estimates made by the ERCB for oil and gas, estimates made by the CPA are not used directly to establish allowable production levels or export availability. Therefore, the CPA has the advantage of approaching the subject with less direct political pressure. This situation also allows the CPA to choose an interpretation of the definition which it feels to be most appropriate and which will lead to a best estimate of established reserves.

The CPA, however, does not have the same access to data or the same manpower as the ERCB. As a result, since 1984 the CPA has obtained information from the ERCB on oil pools smaller than 300,000 cubic metres remaining and gas pools smaller than 600 million cubi

metres remaining. The CPA is thereby able to concentrate its internal efforts on estimates of large oil and gas pools in the province which represents a significant proportion of total reserves.

The CPA has been estimating reserves for many years. The reserves committee of the CPA carries on the tradition and compiles these estimates every year. The CPA estimates provide a check on the work of the ERCB and the NEB as well as a consistent reserves series not only for Alberta but for all of Canada. The CPA makes these estimates available to the public for general use, and uses the Association members themselves when called upon to make submissions to regulatory bodies.

## 5.2 Resource Constraints

Through its membership, the CPA can allocate more resources to the appraisal of a large pool than it can to a small pool simply because of the scale economies of the larger pools. In Alberta there are many smaller pools which would consume considerable resources if they were to be intensely appraised. Since 1984, the CPA has been able to focus its resources on estimating reserves in the larger pools.

Even before 1984, the CPA methodology allowed more emphasis to be placed upon the estimation of larger pools. This allocation of resources is similar to the ERCB system whereby larger pools are appraised by higher authorities. The major difference between the technical methodologies of the two organizations is that the ERCB can allocate more resources towards appraising each and every small pool in the province.

## 5.3 Estimates Over Time

### 5.3.1 Oil

The CPA oil reserves have been adjusted over time as new knowledge and information have been acquired. The CPA oil reserves estimates have generally increased over time due to better recovery and extensions from original discoveries.

A major exception to this was the downward adjustment to the Beaverhill Lake pools in 1980, resulting in large negative additions for that year. Also, during the 1960s, the CPA booked reserves which

included some anticipation of waterflood reserves. These reserves were not always realized, especially with respect to some of the smaller pools, and led to significant downward revisions in later years. The same phenomenon occurred with respect to EOR during the 1970s.

Therefore, despite a general appreciation in oil reserves, the techniques of booking reserves have resulted in some significant downward adjustments over time.

### 5.3.2 Gas

Estimates of natural gas generally fluctuate due to large additions which are combined with intermittant large adjustments both upwards and downwards as a result of previous estimates. Gas estimates fluctuate more than those for oil because oil estimates tend to be increased over time and usually do not have large negative adjustments (1980 excepted). However, the high recovery factors assigned at early stages of gas reserves estimation do not allow a large margin for error and often have to be adjusted downwards.

The large increase in gas reserves recorded in 1984 represents a "catch-up" process in which small pools assessed by the ERCB were included in the CPA data base.

### 5.3.3 Area Threshold

In frontier areas, the recording of established reserves is affected by their distance from active markets. These reserves will not be booked until the amount of reserves discovered in an area reaches a threshold level which justifies the development cost of transportation facilities from that remote area to the market. That is why, even though hydrocarbons have been discovered in remote northern or east coast areas, many of these hydrocarbons are not yet included in estimates of established reserves.

### 5.3.4 Changing Guidelines

Even though the definition of established reserves was clearly stated by the task force of 1978, different organizations still have different interpretations of this definition. The specific precondition that is required before an established reserve is booked may involve a commitment to construct a plant or the existence of a fully

operating plant. The choice of preconditions which must be met before reserves are booked makes a tremendous difference to the estimate of established reserves. The CPA is aware that some water floods during the 1960s and some EOR programs during the 1970s were perhaps booked too soon. The CPA is in the process of clarifying the guidelines under which established reserves will be booked.

### 5.3.5 Presentation

The CPA provides estimates of reserves in the CPA Statistical Handbook. This is updated each year and breaks down Canadian reserves into many different categories. Alberta's reserves are presented in a number of formats: by allocating back to original year of discovery, by additions, by remaining reserves, by initial volume in place each year, by geological age, by type of oil and by method of extraction.

The CPA also presents data in consistent time series form and divides data into product categories. Between the years 1955 and 1983, gross additions are also divided into revisions, extensions and discoveries. With such a thorough display of Canadian and Alberta reserves data, the CPA data provide tremendous scope for analysis.

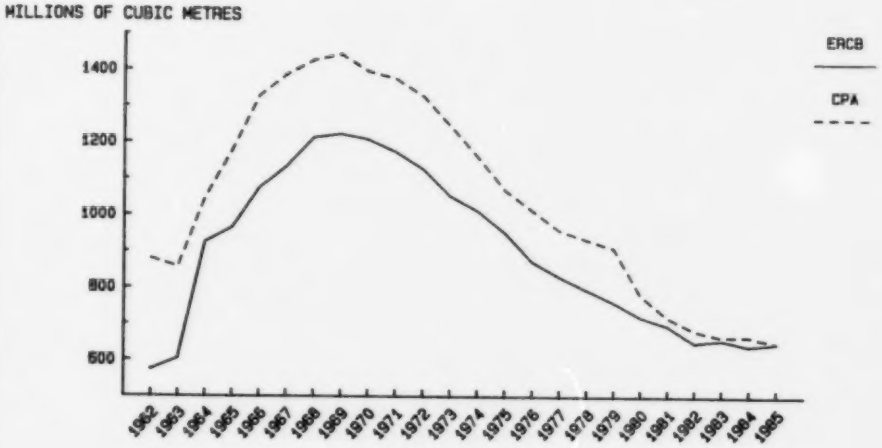
## Chapter 6

## CPA AND ERCB ESTIMATES

### 6.1 Estimates of Established Reserves of Conventional Crude Oil

Figure 6.1 provides an historical comparison of the total remaining established oil reserves for Alberta from 1962 to 1984 as estimated by the CPA and the ERCB.

**FIGURE 6.1**
**REMAINING ESTABLISHED OIL RESERVES IN ALBERTA**




SOURCE: ERCB 86-18, CPA Statistical Handbook, and CERI.

The scale presented above is in millions of cubic metres and begins at 500 million cubic metres. The two estimates follow the same general pattern, rising throughout the 1960s and then beginning to fall in the early 1970s. During the 1960s, the CPA estimates were as much as 200 million cubic metres (15% to 20%) higher than the ERCB estimates

of the same period. The differences diminished gradually during the 1970s but the estimates have rapidly converged during the 1980s.

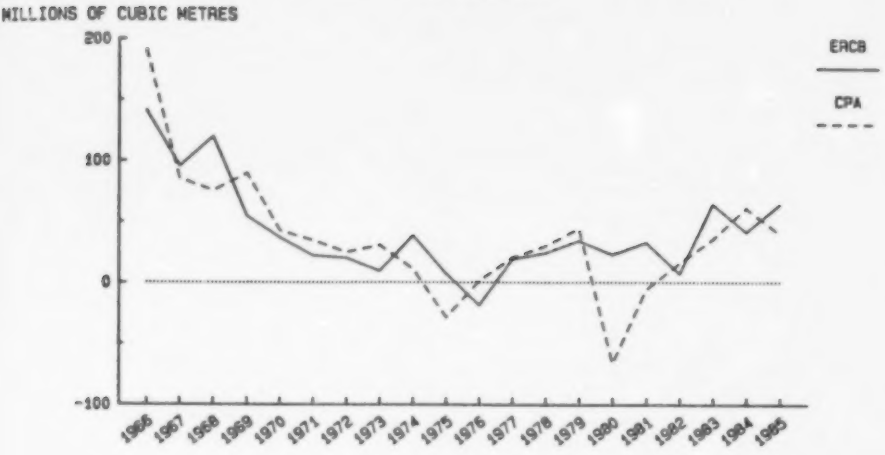
There are several reasons for the higher estimates made by the CPA. One is the different interpretation of the definition of established reserves. The CPA has chosen to "book" (record) established reserves which are expected to be recoverable from water floods and other enhanced recovery techniques at an earlier point than that chosen by the ERCB. The ERCB will not book such reserves until the schemes are actually in place and have had three months of production/injection history. This differs from the approach of the CPA, which historically would book reserves if there was reasonable certainty that the oil could be recovered. Thus the CPA could book reserves if similar pools were obtaining higher recovery from waterfloods or enhanced recovery.

Recently, the interpretation of established reserves has been developed further. During the 1960s, many pools were booked by the CPA for waterflood schemes which were never undertaken, especially in smaller pools. In such situations, the reserves would have to be adjusted downwards when it was decided that waterflooding was unlikely to take place. As a result of these adjustments, the original procedure for booking waterflood reserves was adapted to take account of this better understanding. The same process took place with respect to enhanced recovery.

The CPA is in the process of redefining its interpretation of established reserves recoverable through enhanced oil recovery. In the interim, it is requiring that projects be under construction before the reserves can be booked. This is more rigid than previous interpretations but still results in booking of reserves at an earlier stage than under the ERCB rule.

The practice of booking higher oil reserves during the period beginning in 1964 could have been affected by the new reserves-based prorationing system. Both the ERCB and CPA recorded large reserves increases from 1963 to 1964. In 1964 the ERCB estimates began to catch up to those of the CPA. During the latter part of the 1960s, the CPA estimates continued to accelerate while the ERCB adopted a more conservative position.

## FIGURE 6.2
## ADDITIONS TO ESTABLISHED OIL RESERVES IN ALBERTA



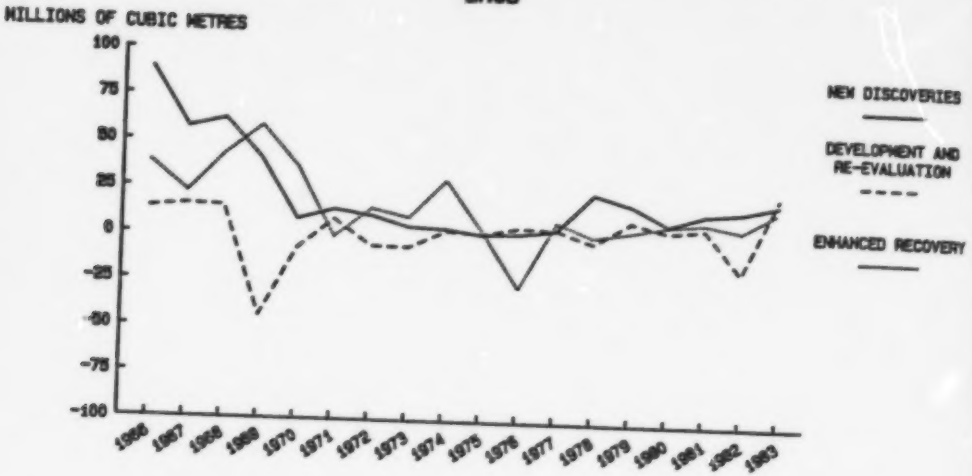

SOURCE: ERCB 86-18, CPA Statistical Handbook, and CERI

As shown in Figure 6.2, total net additions to established oil reserves in Alberta for the CPA and ERCB have been very similar with the exception of the 1980/81 period. As mentioned earlier, this was caused by large negative adjustments by the CPA to the Beaverhill Lake pools.

Figures 6.3 and 6.4 show ERCB and CPA estimates of additions, divided into various subcategories. As shown in Figure 6.3, the ERCB has divided additions into New Discoveries, Development and Re-evaluation, and Enhanced Recovery. By combining re-evaluations with development the ERCB has obscured the effects of isolated development activity.

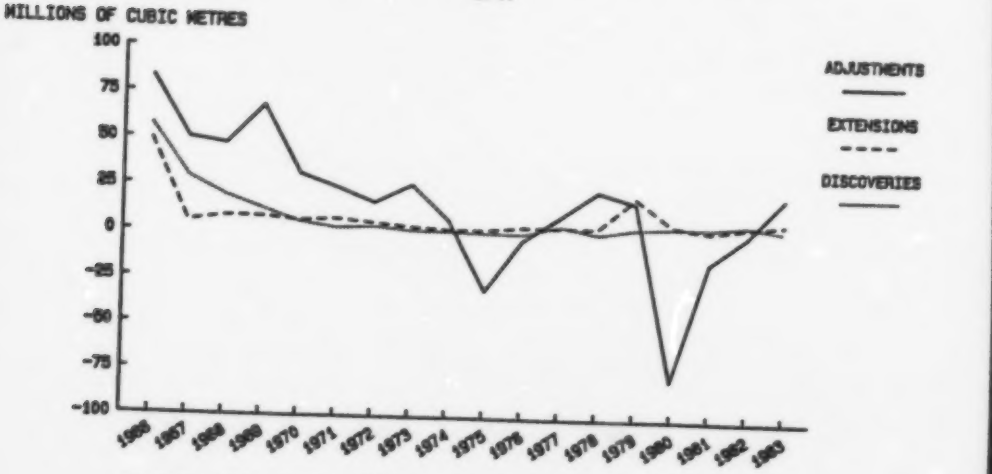
New Discoveries and Development will both cause reserve increases or positive additions. The data show that while the New Discoveries category is always positive, the Development and

FIGURE 6.3
ADDITIONS TO ESTABLISHED OIL RESERVES IN ALBERTA
ERCB




SOURCE: ERCB 86-18, CPA Statistical Handbook, and CERI

FIGURE 6.4
ADDITIONS TO ESTABLISHED OIL RESERVES IN ALBERTA
CPA




SOURCE: ERCB 86-18, CPA Statistical Handbook, and CERI

Re-evaluation category is sometimes negative, particularly in 1969, 1982 and 1984. In these years re-evaluations were so large that they outweighed increases in additions through development. In 1964, there was a very large increase in additions from Re-evaluation and Development. This response marked the beginning of the reserves-based prorationing scheme under which many reassessments began to take place.

In 1964, Enhanced Recovery showed a tremendous increase. Again, this coincided with the beginning of the reserves-based prorationing system when many adjustments and re-assessments were made. In 1976, Enhanced Recovery showed a large negative value for additions. This was also the result of a reassessment.

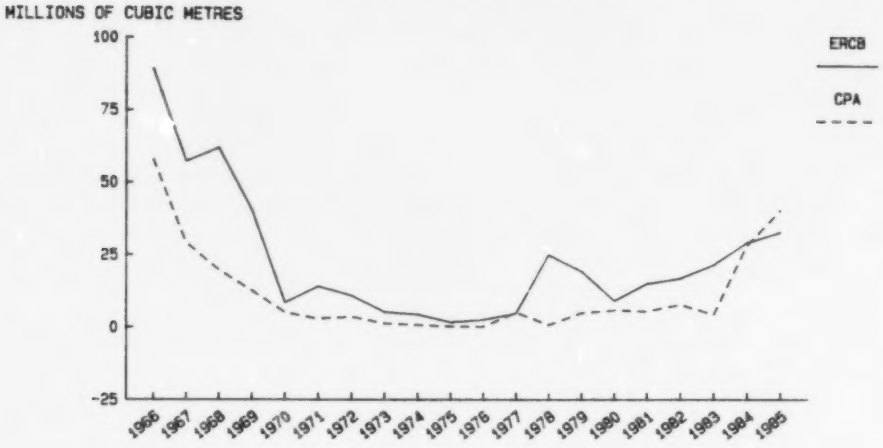
The New Discoveries category, as presented by the ERCB, represents an estimate of the discoveries which have been made during that year. These additions rose significantly during the late 1960s, declined in the mid-1970s and rose again during 1978/79, as oil prices increased for the second time. Since 1980 they have continued to increase. This has likely been caused by a renewed emphasis on oil exploration.

As shown in Figure 6.4, the CPA isolates Adjustments from Extensions and Discoveries, unlike the presentation of the ERCB. Using this technique, one can observe fairly flat and constant additions from exploratory and development activity. Major shifts come almost entirely from adjustments. Adjustments tended to be above zero in the 1960s but became significantly negative during the mid-1970s and early 1980s as large previous estimates were adjusted downwards.

The CPA Discoveries and Extensions (estimates) category follows a similar pattern to that of the ERCB. Additions were high during the 1960s, falling during the early 1970s and tending to rise again in the late 1970s. The large increase in Extensions in 1979 seems to mirror the large increase in New Discoveries in 1978/79 in the ERCB estimates.

An interesting comparison between the ERCB and CPA estimates is shown in Figure 6.5, where additions due to New Discoveries are compared. Although they have followed the same pattern, the ERCB reserve additions resulting from New Discoveries have been consistently greater than those of the CPA.

## FIGURE 6.5
## ADDITIONS TO ESTABLISHED OIL RESERVES IN ALBERTA DUE TO NEW DISCOVERIES




SOURCE: ERCB 86-18, CPA Statistical Handbook, and CERI

Turning back to Figure 6.3, it can be seen that ERCB New Discoveries are generally higher than Development and Re-evaluation. Yet, looking at Figure 6.4, we see that CPA Adjustments are frequently higher than Discoveries. This discrepancy may result from the ERCB's method of recording New Discoveries, which groups reserves associated with the discovery well with the reserves associated with development wells drilled within the same calendar year on the same site. This results in a higher figure for ERCB New Discoveries reserves.

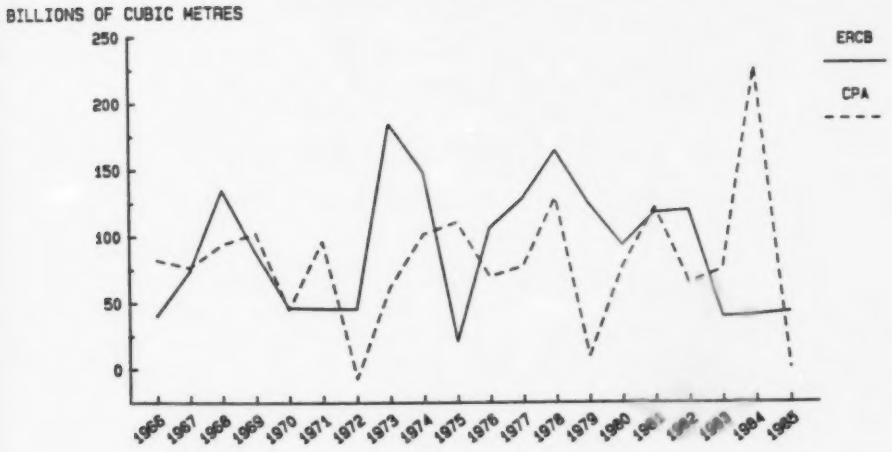
Since, as shown in Figure 6.5, ERCB New Discoveries are always higher than CPA Discoveries, but total additions, as shown in Figure 6.2, tend to be very close, the implication is obvious that CPA extensions and re-evaluation reserve additions are greater than ERCB development and re-evaluation and enhanced recovery reserve additions. Due to timing of the reserve evaluations, some CPA New Discoveries were likely included in the following year's revisions. The relatively higher level of CPA adjustments shown in Figure 6.4 is therefore not surprising.

Another explanation of the difference in discoveries could be the difference in estimates for smaller pools in Alberta. Figure 6.2 shows an increase in CPA oil reserves in 1984. This was considered to be a small pools "catch up" adjustment as the CPA adopted the ERCB data base for small pools.

### 6.2 Estimates of Marketable Natural Gas

Figure 6.6 provides an ERCB/CPA comparison of Additions to Established Reserves of Marketable Gas in Alberta.

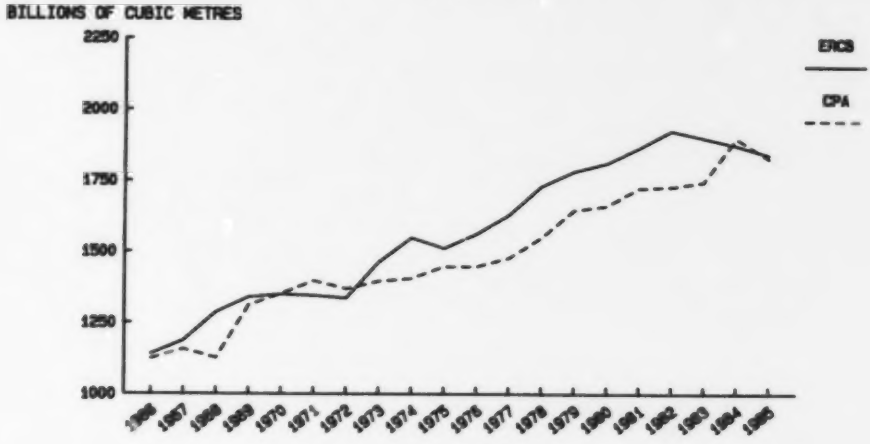
FIGURE 6.6
ADDITIONS TO ESTABLISHED RESERVES
OF MARKETABLE GAS IN ALBERTA




SOURCE: ERCB 86-18, CPA Statistical Handbook, and CERI

The large shifts in additions recorded by both the CPA and the ERCB are caused by adjustments which are particularly prevalent in gas reserves estimation (see Figure 6.6). As outlined by the ERCB's special report on gas reserves estimates, major studies of gas reserves cause significant adjustments in the estimates. If we isolate adjustments from other additions, as shown in Figures 6.8 and 6.9, the growth in discoveries has been rather stable while the adjustments tend to exhibit large sporadic shifts. Since the ERCB and CPA adjustments

## FIGURE 6.7
## REMAINING ESTABLISHED RESERVES OF MARKETABLE GAS IN ALBERTA



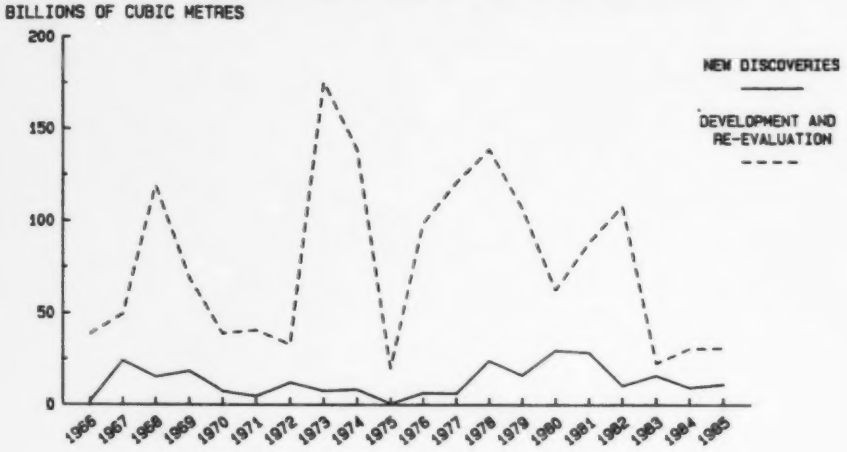

SOURCE: ERCB 86-18, CPA Statistical Handbook, and CERI

coincide with special studies rather than specific economic or other factors, there is little reason to assume that total additions would shift at the same time. Therefore it is important to look at the disaggregated data.

Historically, there have been significant differences of opinion concerning the volume of Reserve Additions of Natural Gas. However, if we look at Figure 6.7, the remaining established reserves for the years 1984 and 1985 are very close.

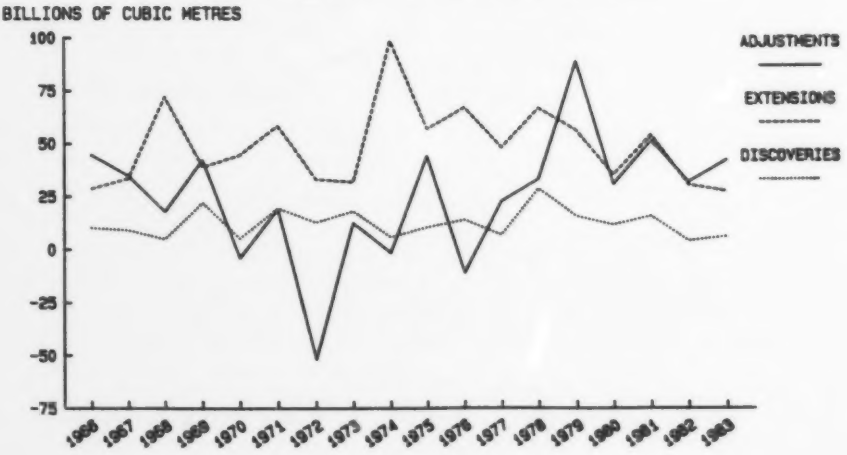
As shown in Figure 6.9, the CPA has presented historical data dividing additions into three categories: adjustments, extensions and discoveries. This presentation makes it possible to isolate the effects of adjustments from the effects of extensions. Clearly, adjustments can cause large deviations from otherwise consistent additions. As shown in Figure 6.8, the ERCB combines development and re-evaluation into one series which corresponds to the CPA categories

## FIGURE 6.8
## ADDITIONS TO ESTABLISHED RESERVES OF MARKETABLE GAS IN ALBERTA, ERCB



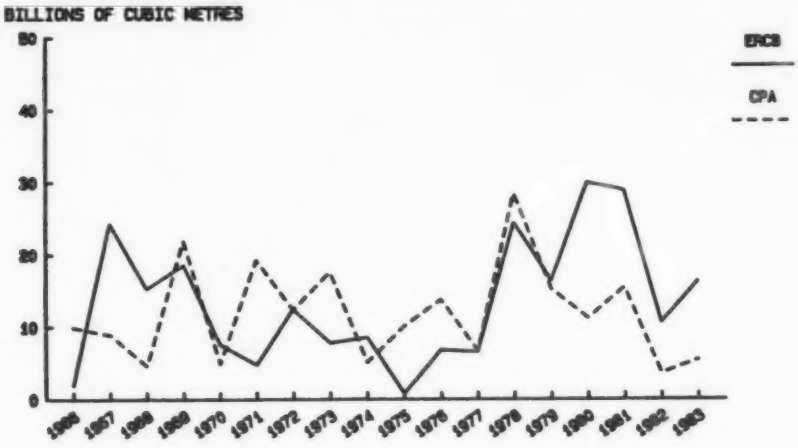

SOURCE: ERCB 86-18, CPA Statistical Handbook, and CERI

## FIGURE 6.9
## ADDITIONS TO ESTABLISHED RESERVES OF MARKETABLE GAS IN ALBERTA, CPA




SOURCE: ERCB 86-18, CPA Statistical Handbook, and CERI

**FIGURE 6.10**
**RESERVE ADDITIONS DUE TO NEW DISCOVERIES**
**GAS**




SOURCE: ERCB 86-18, CPA Statistical Handbook, and CERI

of extensions and adjustments. This results in additional variance in the Development and Re-evaluation data series. The variance is caused by studies which are done as errors are discovered and creates biased noise in the development data. Again, the comparison between ERCB and CPA estimates of new discoveries of marketable gas is possible without any data manipulation. This comparison is presented in Figure 6.10.

### 6.3 Oil Sands

The ERCB and CPA both publish estimates of Surface-Mineable Crude Bitumen and Synthetic Crude Oil Reserves. The 1984 and 1985 estimates of the two organizations are presented on the following two pages and summarized in Tables 6.1 and 6.2. Based upon the independent estimates which have been made, there does not seem to be any significant difference in the estimates of Synthetic Oil Reserves.

TABLE 6.1

ESTABLISHED RESERVES OF SYNTHETIC OIL
COMPARISON
(millions of cubic metres)

| YEAR OF ESTIMATE | | E R C B | C P A |
|---|---|---|---|
| 1984 | Initial Volume in Place | 444.000 | 557.391 |
| | Initial Established | 388.000 | 334.059 |
| | Remaining | 291.000 | 265.972 |
| 1985 | Initial Volume in Place | 444.000 | 557.391 |
| | Initial Established | 388.000 | 334.059 |
| | Remaining | 282.000 | 256.227 |

SOURCE: ERCB 86-18 and CPA Statistical Handbook

### 6.4 In-Situ Crude Bitumen Reserves

The in-situ crude bitumen reserves estimates provided by the CPA and the ERCB are quite different. The numbers provided for 1984 show the ERCB estimates to be three times those of the CPA. This difference is caused primarily by confidentiality restrictions placed upon the CPA during 1984 with respect to obtaining data.

The numbers for 1985 are also quite different, the CPA estimates being substantially higher than those of the ERCB. This large change in the relationship from 1984 to 1985 was caused by the different approaches taken by the ERCB and CPA with respect to the timing of reserves booking. The ERCB will only book reserves on the basis of approved in-situ projects. The CPA, however, will include reserves which do not have a continual approval but which are likely to be produceable without further capital expenditures.

A further factor underlying these differences involves a different interpretation of "development." Reserves are only booked by

the ERCB when the necessary wells have been drilled and completed. In addition, there are probably differences in recovery factors and other technical estimates.

Generally, the ERCB is likely to "catch up" to the CPA's reserves bookings as more projects are entirely developed. The high CPA estimate of in-situ reserves is consistent with the higher estimates of conventional oil during the 1960s and early 1970s.

### 6.5 Natural Gas Liquids

Estimates of reserves of natural gas liquids are presented annually by the CPA and the ERCB. The ERCB classifies NGLs as propane, butanes and pentanes plus. The CPA combines propane, butanes and ethane and presents pentanes plus separately.

The ERCB method of estimating Natural Gas Liquids is based upon a computer modelling system called GEMM (Gas Energy Management Model). This system contains a large data base and a pool analysis system which includes all plants' historical recovery rates. In this way the ERCB obtains complete and sophisticated estimates for all Natural Gas Liquids including those reserves recoverable at reprocessing plants.

The CPA estimates pentanes plus without including that portion recoverable at reprocessing plants. Therefore the ERCB number, presented in Table 6.3, of 120.1 million cubic metres, should be reduced to 111.5 million cubic metres to be comparable with the 129.187 million cubic metres estimated by the CPA.

Currently, there is no significant difference in these estimates of established reserves of pentanes plus, however, recent additions booked by the CPA have reduced the former differences. This change is likely due to the added data in 1985 for smaller pools first included by the CPA in 1984.

Table 6.4 shows CPA estimates of reserves of ethane, propane and butanes for 1984 and 1985, and ERCB estimates of propane and butanes for 1984 and 1985.

The CPA total includes ethane from only four field gas plants. Ethane is not included in the ERCB estimate in Table 6.4 because the ERCB includes <u>all</u> fields in Alberta in its ethane estimate. ERCB estimates of ethane--321 million cubic metres (liquid)--are presented

TABLE 6.2

IN-SITU RESERVES
(millions of cubic metres)

| YEAR OF ESTIMATE | | E R C B | C P A |
|---|---|---|---|
| 1984 | Initial Established | 42.100 | 13.010 |
| | Remaining Established | N/A | 6.370 |
| 1985 | Initial Established | 72.200 | 146.069 |
| | Remaining Established | 59.600 | 136.500 |

SOURCE: ERCB 86-18 and CPA Statistical Handbook

TABLE 6.3

PENTANES PLUS RESERVES
(millions of cubic metres)

| YEAR OF ESTIMATE | | E R C B | C P A |
|---|---|---|---|
| 1984 | Remaining Reserves | 124.9 | 96.6 |
| | Additions | 1.0 | 38.4 |
| | Production | 5.8 | 5.8 |
| 1985 | Remaining Reserves | 120.1 | 129.2 |

SOURCE: ERCB 86-18 and CPA Statistical Handbook

TABLE 6.4
LIQUIFIED PETROLEUM GASES RESERVES

CPA

ETHANE, PROPANE, BUTANES
(millions of cubic metres)

| YEAR OF ESTIMATE | | C P A |
|---|---|---|
| 1984 | Remaining Reserves | 131.5 |
| | Additions | 41.2 |
| | Production | 8.8 |
| 1985 | Remaining Reserves | 163.9 |

ERCB

PROPANE AND BUTANES
(millions of cubic metres)

| YEAR OF ESTIMATE | | PROPANE | BUTANES | TOTAL |
|---|---|---|---|---|
| 1984 | Remaining Reserves | 126.5 | 71.8 | 198.3 |
| | Additions | 4.6 | 1.7 | 6.3 |
| | Production | 5.5 | 3.1 | 8.6 |
| 1985 | Remaining Reserves | 125.6 | 70.4 | 196.0 |

SOURCE: ERCB 86-18 and CPA Statistical Handbook

separately. In order to compare CPA and ERCB LPG estimates, it is therefore necessary to adjust the ERCB figure by adding an amount which represents the ethane included in the CPA estimate.

Another difference between the two estimates is the inclusion by the ERCB of LPGs recoverable at reprocessing plants. Again, this amount must be subtracted from the ERCB figure in order to compare the CPA and ERCB estimates (See Table 6.5).

TABLE 6.5

COMPARISON OF NATURAL GAS LIQUIDS RESERVES
AS PRESENTED BY THE ERCB AND CPA

| YEAR OF ESTIMATE | | |
|---|---|---|
| 1985 | **Remaining Reserves - CPA** (Ethane, Propane, Butanes) ..... | 163.9 |
| 1985 | **Remaining Reserves - ERCB** (Ethane, Propane, Butanes) | 196.0 |
| | 196.0 (Table 6.4 - Remaining Reserves ERCB) | |
| | - 73.0 Subtract Amounts from Reprocessing Plants (ERCB ST 86-18, Page 6-12)(Propane + Butanes) | |
| | 123.0 SUBTOTAL | |
| | + 21.0 Add amounts of ethane from plants included CPA (ERCB ST 86-18, Page 5-2)[1] | |
| | 144.0 TOTAL | |
| | ERCB Comparable Estimate ..... | 144.0 |

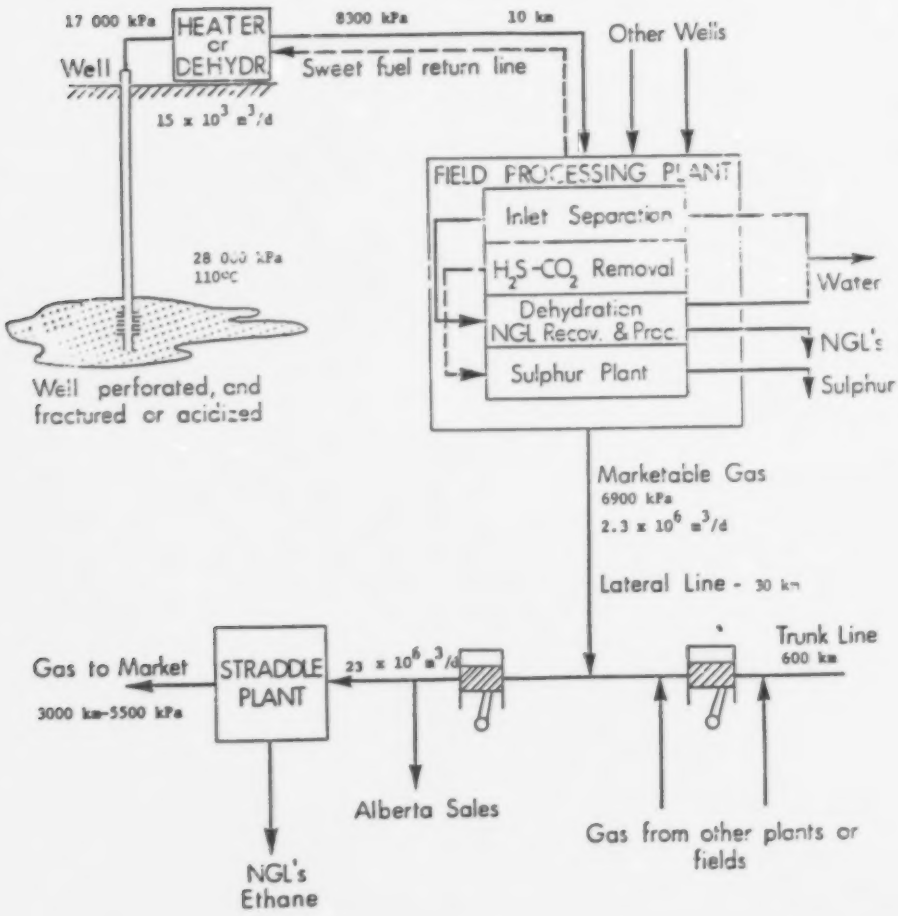
SOURCE: Canadian Energy Research Institute

Notice that once the numbers are reconciled, the CPA estimate (163 $10^6 m^3$) is higher than the ERCB estimate (144 $10^6 m^3$).

In order to understand the differences between these estimates, a description of the processing structure of NGL is presented below in Figure 6.11.

FIGURE 6.11

THE PRODUCTION OF NATURAL GAS LIQUIDS




SOURCE: ERCB, Gas Department

## 6.6 Sulphur

The CPA and ERCB both divide sulphur reserves into two categories: sulphur from crude bitumen and sulphur from natural gas. The CPA provides data on sulphur broken down by province and geological age and by year of discovery. Annual production revisions and additions are provided in its report section.

The ERCB provides sulphur statistics broken down by each field and producing area in Alberta, and provides annual additions and production figures. A comparison of the initial remaining established reserves of sulphur estimated by the ERCB and CPA as outlined in Table 6.6 shows no significant difference in 1985.

TABLE 6.6

RESERVES OF SULPHUR
(million tonnes)

| YEAR OF ESTIMATE | | E R C B | C P A |
|---|---|---|---|
| 1984 | Remaining as of December 31 | 93.70 | 81.24 |
| | Gross Additions | 3.30 | 7.14 |
| | Production | 5.40 | 5.00 |
| 1985 | Remaining Reserves December | 84.98 | 83.35 |

SOURCE: ERCB 86-18 and CPA Statistical Handbook

## 6.7 Ultimate Potential

### 6.7.1 ERCB

There is a chapter in the ERCB publication, "Alberta's Reserves of Crude Oil, Oil Sands, Gas, Natural Gas Liquids and Sulphur"[2], which deals with Ultimate Potential. Ultimate potential is estimated for Conventional Crude Oil, Crude Bitumen and Synthetic Crude Oil, Marketable Gas, Ethane, Natural Gas Liquids and Sulphur.

The estimates of ultimate potential are made using general geological knowledge of Alberta and the sum of experience and information which has become available from the beginning of exploration in Alberta. The ERCB published summaries of initial and remaining established reserves of marketable gas and conventional crude oil. These summaries are presented in Figures 6.12 (a) and (b), and 6.13 (a) and (b).

The ERCB then uses these series of initial established reserves to forecast the likely future initial established reserves. This forecast is based upon an assumed drilling activity rate and the information accumulated by the ERCB.

The slope of the Oil forecast is not quite as steep as that of the Natural Gas forecast. This may demonstrate the long term perception that the ultimate potential for gas relative to the percentage already established is expected to be greater than the ultimate potential for oil.

6.7.2 CPA

The CPA approaches ultimate potential by publishing initial established reserves, by year of discovery as shown in Figures 6.14 (a) and (b). It has done this annually since 1947. Using this information, the appreciation factors over time can be calculated and estimates can be made of likely future additions of both oil and gas.

This methodology allows one to observe the trends over time without having to continually adjust for re-assessments. By taking a yearly series of these estimates as presented in CERI Research Report 85-1, ESTIMATED PETROLEUM FINDING COSTS IN ALBERTA 1970-1983, appreciation factors can be calculated and forecasts of appreciation can be made. The ERCB performs this process for gas reserves, but they have stopped doing so for oil.

The CPA has prepared specific reports on Ultimate Potential. In May 1980, a report entitled Oil Potential, Crude Oil and Pentanes Plus, was presented in ERCB Proceeding Number 800065.

The CPA also presented a report to the NEB Hearing on Energy Supply/Demand. The NEB order number was EHR-1-80, dated September 5, 1980. This report contains an ultimate potential estimate by province. An update to this report was filed with the NEB in February 1984, however this update did not contain provincial breakouts.

FIGURE 6.12 (a)

ERCB Table 8-1

**TABLE 8-1 SUMMARY OF INITIAL AND REMAINING ESTABLISHED RESERVES OF CONVENTIONAL CRUDE OIL**
**As of Each Year-end**
**millions of cubic metres**

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Year | Initial Established | | Production | | Remaining Established[a] |
| | Addition | Cumulative[a] | Annual | Cumulative[a] | |
| 1951 | 44.5 | 219.3 | 7.3 | 29.4 | 189.9 |
| 1952 | 62.5 | 281.7 | 9.3 | 38.8 | 243.0 |
| 1953 | 66.6 | 348.3 | 12.2 | 51.0 | 297.3 |
| 1954 | 55.6 | 403.9 | 13.9 | 65.0 | 339.0 |
| 1955 | 68.2 | 472.1 | 17.9 | 82.8 | 389.3 |
| 1956 | 82.0 | 554.1 | 22.8 | 105.7 | 448.4 |
| 1957 | 39.9 | 594.0 | 21.7 | 127.4 | 466.6 |
| 1958 | 1.4 | 595.4 | 17.9 | 145.2 | 450.2 |
| 1959 | 67.5 | 663.0 | 20.5 | 165.7 | 497.2 |
| 1960 | 48.6 | 711.6 | 20.7 | 186.6 | 525.0 |
| 1961 | 57.5 | 769.1 | 25.1 | 211.5 | 557.6 |
| 1962 | 44.0 | 813.5 | 26.2 | 237.9 | 575.6 |
| 1963 | 56.6 | 870.0 | 26.8 | 264.6 | 605.4 |
| 1964 | 348.5 | 1 218.5 | 27.9 | 292.4 | 926.1 |
| 1965 | 68.8 | 1 287.3 | 29.2 | 321.6 | 965.7 |
| 1966 | 140.8 | 1 428.1 | 32.2 | 353.9 | 1 074.2 |
| 1967 | 95.2 | 1 523.3 | 36.6 | 390.4 | 1 132.9 |
| 1968 | 119.8 | 1 643.1 | 39.8 | 430.3 | 1 212.8 |
| 1969 | 54.5 | 1 697.6 | 44.4 | 474.7 | 1 222.8 |
| 1970 | 36.7 | 1 734.3 | 51.7 | 526.5 | 1 207.9 |
| 1971 | 22.1 | 1 756.4 | 56.4 | 582.9 | 1 173.6 |
| 1972 | 20.0 | 1 776.5 | 67.4 | 650.0 | 1 126.0 |
| 1973 | 9.2 | 1 785.7 | 83.3 | 733.7 | 1 052.0 |
| 1974 | 38.5 | 1 824.1 | 79.0 | 812.7 | 1 011.5 |
| 1975 | 7.0 | 1 831.1 | 67.5 | 880.2 | 950.9 |
| 1976 | -18.6 | 1 812.5 | 61.0 | 941.2 | 871.3 |
| 1977 | 19.1 | 1 831.6 | 60.4 | 1 001.6 | 830.0 |
| 1978 | 24.4 | 1 856.0 | 60.0 | 1 061.6 | 794.5 |
| 1979 | 34.3 | 1 890.3 | 68.5 | 1 130.1 | 760.2 |
| 1980 | 22.7 | 1 913.2 | 63.2 | 1 193.3 | 719.9 |
| 1981 | 32.6 | 1 945.8 | 56.5 | 1 249.8 | 696.0 |
| 1982 | 6.9 | 1 952.7 | 53.6 | 1 303.4 | 649.4 |
| 1983 | 64.1 | 2 016.8 | 55.6 | 1 359.0 | 657.8 |
| 1984 | 42.0 | 2 058.8 | 59.2 | 1 418.2 | 640.7 |
| 1985 | 64.0 | 2 122.8 | 56.2 | 1 474.4 | 648.5 |
| | | (13.4)[b] | | | (4.1)[b] |

SOURCE: ERCB Report 85-A

FIGURE 6.12 (b)

ERCB Figure 8-1

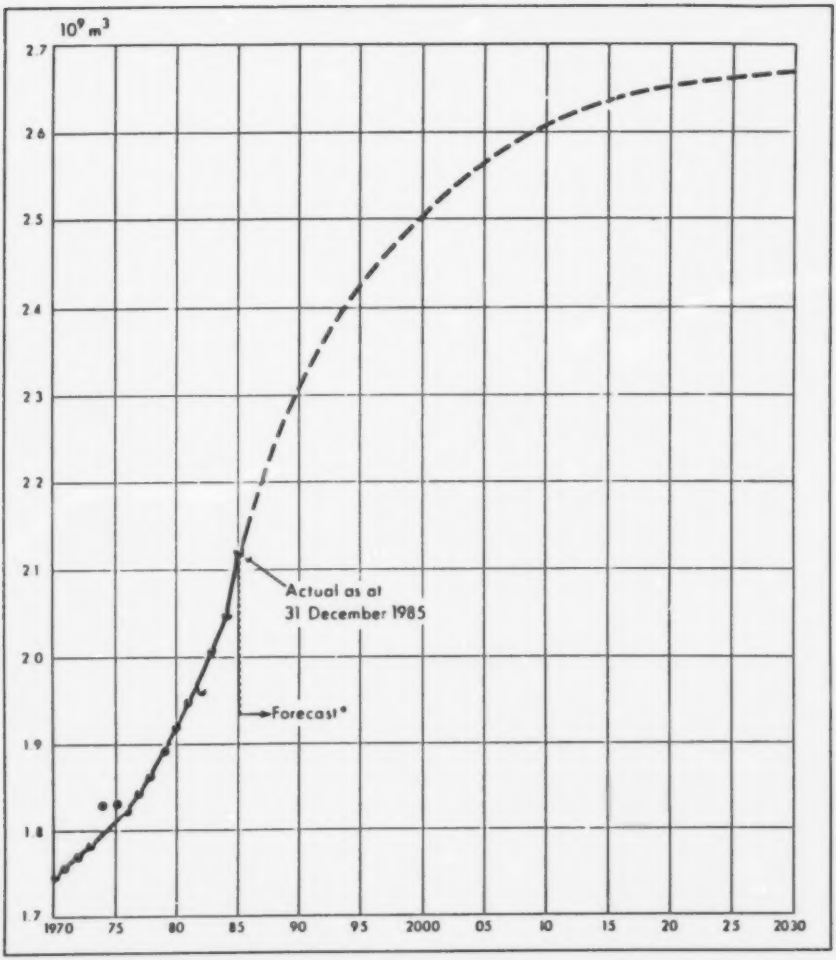



FIGURE 8-1 FORECAST GROWTH OF INITIAL ESTABLISHED RESERVES OF CONVENTIONAL CRUDE OIL

SOURCE: ERCB Report 85-A

FIGURE 6.13 (a)

ERCB Table 8-2

TABLE 8-2 SUMMARY OF INITIAL AND REMAINING ESTABLISHED RESERVES OF MARKETABLE GAS
As of Each Year-end
billions of cubic metres

| Year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| | Initial Established | | Production | | Remaining Established[a] | |
| | Additions | Cumulative[a] | Annual | Cumulative[a] | Actual[a] | 37.4 MJ/m³ |
| 1951 | 61.2 | 205.5 | 1.6 | 19.4 | 186.1 | • |
| 1952 | 87.8 | 293.4 | 1.8 | 21.2 | 272.1 | • |
| 1953 | 76.1 | 369.5 | 2.0 | 23.3 | 346.2 | • |
| 1954 | 58.8 | 428.3 | 2.5 | 25.8 | 402.5 | • |
| 1955 | 59.3 | 487.6 | 3.0 | 28.8 | 458.8 | • |
| 1956 | 64.5 | 552.2 | 3.2 | 32.0 | 520.1 | • |
| 1957 | 64.9 | 617.1 | 3.8 | 35.8 | 581.7 | • |
| 1958 | 110.4 | 727.5 | 5.3 | 41.1 | 686.4 | 721.2 |
| 1959 | 88.5 | 816.0 | 7.1 | 48.2 | 767.8 | 809.8 |
| 1960 | 119.9 | 935.9 | 9.1 | 57.4 | 878.6 | 926.8 |
| 1961 | 13.3 | 949.2 | 11.9 | 69.3 | 879.9 | 930.5 |
| 1962 | 49.7 | 998.9 | 17.6 | 86.9 | 912.1 | 964.2 |
| 1963 | 35.8 | 1 034.7 | 19.6 | 106.5 | 928.2 | 980.0 |
| 1964 | 85.9 | 1 120.6 | 22.1 | 128.6 | 992.0 | 1 052.6 |
| 1965 | 89.7 | 1 210.4 | 24.2 | 152.8 | 1 057.6 | 1 129.6 |
| 1966 | 40.6 | 1 251.0 | 25.5 | 178.3 | 1 072.6 | 1 142.5 |
| 1967 | 73.9 | 1 324.9 | 27.5 | 205.8 | 1 119.1 | 1 189.6 |
| 1968 | 134.6 | 1 459.5 | 30.0 | 235.8 | 1 223.6 | 1 289.0 |
| 1969 | 87.5 | 1 547.0 | 37.8 | 273.6 | 1 273.4 | 1 342.6 |
| 1970 | 46.2 | 1 593.2 | 40.1 | 313.8 | 1 279.4 | 1 352.0 |
| 1971 | 45.4 | 1 638.6 | 48.5 | 362.3 | 1 276.3 | 1 346.9 |
| 1972 | 45.2 | 1 683.9 | 52.4 | 414.7 | 1 269.1 | 1 337.6 |
| 1973 | 183.3 | 1 867.2 | 56.0 | 470.7 | 1 396.6 | 1 464.5 |
| 1974 | 147.0 | 2 014.2 | 57.0 | 527.8 | 1 486.5 | 1 550.2 |
| 1975 | 20.8 | 2 035.1 | 56.6 | 584.3 | 1 450.8 | 1 512.8 |
| 1976 | 105.6 | 2 140.7 | 54.6 | 639.0 | 1 501.7 | 1 563.9 |
| 1977 | 127.6 | 2 268.2 | 61.0 | 700.0 | 1 568.3 | 1 630.3 |
| 1978 | 163.3 | 2 431.6 | 66.4 | 766.3 | 1 665.2 | 1 730.9 |
| 1979 | 123.2 | 2 554.7 | 70.0 | 836.4 | 1 718.4 | 1 783.1 |
| 1980 | 92.4 | 2 647.1 | 63.8 | 900.2 | 1 747.0 | 1 812.1 |
| 1981 | 117.0 | 2 764.1 | 68.6 | 968.8 | 1 795.3 | 1 864.8 |
| 1982 | 118.7 | 2 882.8 | 60.9 | 1 029.7 | 1 853.1 | 1 924.6 |
| 1983 | 39.0 | 2 921.8 | 66.0 | 1 095.6 | 1 826.2 | 1 898.7 |
| 1984 | 40.5 | 2 962.3 | 68.3 | 1 163.9 | 1 798.4 | 1 872.2 |
| 1985 | 42.6 | 3 004.9 | 72.8 | 1 236.7 | 1 768.3 | 1 840.0 |
| | | (106.7)[b] | | | (62.8)[b] | (65.3)[b] |

SOURCE: ERCB ST-18

FIGURE 6.13 (b)

ERCB Figure 8-2

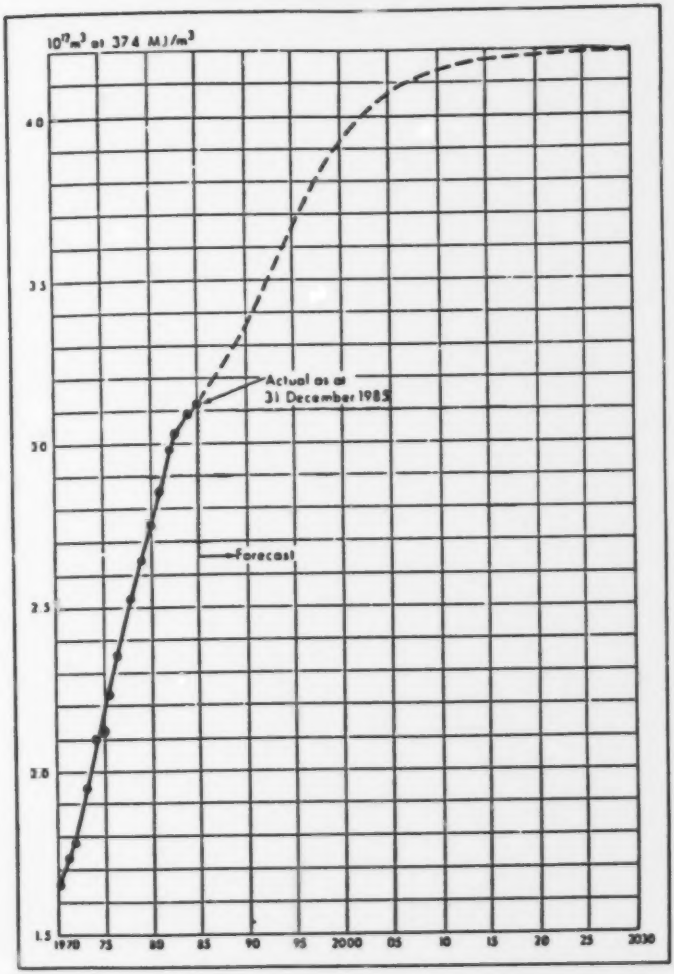



FIGURE 8-2 FORECAST GROWTH OF INITIAL ESTABLISHED RESERVES OF MARKETABLE GAS

SOURCE: ERCB ST-18

FIGURE 6.14 (a)

CPA Table 17

# CRUDE OIL
# INITIAL VOLUME IN-PLACE BY YEAR OF DISCOVERY
# AT 1985-12-31

Thousand Cubic Metres

| | PROVINCES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR OF DISCOVERY | MAIN YUKON | MAC DELTA BEAU SEA | ARCTIC ISLES | BC | ALTA | SASK | MAN | ONT | OTHER EAST CAN. | E. COAST OFFSHORE | TOTAL CANADA |
| PRE 1947 | 87500 | 0 | 0 | 0 | 414430 | 0 | 0 | 22603 | 2860 | 0 | 527392 |
| 1947 | 0 | 0 | 0 | 0 | 119540 | 13966 | 0 | 0 | 0 | 0 | 265815 |
| 1948 | 0 | 0 | 0 | 0 | 250805 | 15750 | 0 | 0 | 0 | 0 | 149367 |
| 1949 | 0 | 0 | 0 | 0 | 117989 | 26380 | 0 | 5074 | 0 | 0 | 128328 |
| 1950 | 0 | 0 | 0 | 0 | 123999 | 6278 | 0 | 1051 | 0 | 0 | 446923 |
| 1951 | 0 | 0 | 0 | 0 | 261105 | 154168 | 31431 | 219 | 0 | 0 | 304524 |
| 1952 | 0 | 0 | 0 | 1378 | 189872 | 110217 | 2671 | 384 | 0 | 0 | 1560909 |
| 1953 | 0 | 0 | 0 | 0 | 1287525 | 198331 | 74350 | 503 | 0 | 0 | 625660 |
| 1954 | 0 | 0 | 0 | 0 | 186587 | 135917 | 3154 | 0 | 0 | 0 | 338214 |
| 1955 | 0 | 0 | 0 | 87252 | 66455 | 168208 | 13321 | 678 | 0 | 0 | 452879 |
| 1956 | 0 | 0 | 0 | 6276 | 131932 | 314068 | 625 | 0 | 0 | 0 | 583757 |
| 1957 | 0 | 0 | 0 | 16176 | 510378 | 51967 | 2960 | 284 | 0 | 0 | 163601 |
| 1958 | 0 | 0 | 0 | 6767 | 146068 | 3579 | 0 | 787 | 0 | 0 | 595212 |
| 1959 | 0 | 0 | 0 | 12613 | 68383 | 97068 | 0 | 788 | 0 | 0 | 131758 |
| 1960 | 0 | 0 | 0 | 6971 | 39273 | 83187 | 0 | 2407 | 0 | 0 | 110432 |
| 1961 | 0 | 0 | 0 | 561 | 78935 | 305+8 | 0 | 416 | 0 | 0 | 151205 |
| 1962 | 0 | 0 | 0 | 1981 | 112356 | 3+174 | 1389 | 1467 | 0 | 0 | 372634 |
| 1963 | 0 | 0 | 0 | 1092 | 20+818 | 1+0397 | 0 | 327 | 0 | 0 | 345088 |
| 1964 | 0 | 0 | 0 | 11792 | 224927 | 103822 | 0 | 547 | 0 | 0 | 382854 |
| 1965 | 0 | 0 | 0 | 1+638 | 201995 | 83871 | 0 | 350 | 0 | 0 | 213578 |
| 1966 | 0 | 0 | 0 | 20529 | 179759 | 12822 | 0 | 428 | 0 | 0 | 239535 |
| 1967 | 0 | 0 | 0 | 2265 | 156552 | 50533 | 31505 | 640 | 0 | 0 | 191695 |
| 1968 | 0 | 0 | 0 | 1052 | 106915 | 85722 | 0 | 0 | 0 | 0 | 187856 |
| 1969 | 0 | 0 | 0 | 198 | 131458 | 55071 | 0 | 1137 | 0 | 0 | 104969 |
| 1970 | 0 | 0 | 0 | 7760 | 29195 | 67984 | 0 | 0 | 0 | 0 | 99753 |
| 1971 | 0 | 0 | 0 | 2599 | 53530 | 43618 | 0 | 0 | 0 | 0 | 58109 |
| 1972 | 0 | 0 | 0 | 3961 | 34298 | 19523 | 0 | 327 | 0 | 0 | 137708 |
| 1973 | 0 | 0 | 0 | 10423 | 117163 | 18122 | 0 | 0 | 0 | 0 | 90490 |
| 1974 | 0 | 0 | 230 | 318 | 43378 | 44540 | 0 | 0 | 0 | 0 | 20681 |
| 1975 | 0 | 0 | 0 | 0 | 28418 | 0 | 0 | 263 | 0 | 0 | 150498 |
| 1976 | 0 | 0 | 0 | 2631+ | 97851 | 24935 | 0 | 0 | 0 | 0 | 162841 |
| 1977 | 0 | 0 | 0 | 3167 | 132039 | 27593 | 0 | 72 | 0 | 0 | 194475 |
| 1978 | 0 | 0 | 0 | 6453 | 165688 | 22265 | 0 | 157 | 0 | 450000 | 607181 |
| 1979 | 0 | 0 | 0 | 1133 | 120467 | 35+48 | 0 | 181 | 0 | 0 | 131930 |
| 1980 | 0 | 0 | 0 | 703 | 107397 | 23818 | 0 | 12 | 0 | 0 | 101645 |
| 1981 | 0 | 0 | 0 | 482 | 75386 | 25879 | 0 | 0 | 0 | 0 | 187358 |
| 1982 | 0 | 0 | 0 | 478 | 149437 | 37102 | 362 | 180 | 0 | 0 | 166458 |
| 1983 | 0 | 0 | 0 | 531 | 150827 | 9100 | 0 | 0 | 0 | 0 | 112578 |
| 1984 | 0 | 0 | 0 | 11013 | 90208 | 4288 | 0 | 1157 | 0 | 0 | 308330 |
| 1985 | 0 | 0 | 0 | 1943 | 268398 | 19969 | 0 | 0 | 0 | 0 | |
| TOTALS | 87500 | 0 | 250 | 270925 | 7492900 | 2726878 | 161936 | 42448 | 2860 | 450000 | 11237727 |

SOURCE: CPA Statistical Handbook

FIGURE 6.14 (b)

CPA Table 23

# MARKETABLE NATURAL GAS
# INITIAL ESTABLISHED RESERVES IN CANADA BY YEAR OF DISCOVERY
# AT 1985-12-31

Million Cubic Metres at 101 325 kPa and 15°C

| | PROVINCES | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR OF DISCOVERY | MAIN TERR | MAC DELTA BEAU SEA | ARCTIC ISLES | BC | ALTA | SASK | MAN | ONT | OFFSHORE EAST CAN. | E. COAST OFFSHORE | TOTAL CANADA |
| PRE 1967 | 628 | 0 | 0 | 0 | 813580 | 3896 | 0 | 23223 | 884 | 0 | 442263 |
| 1967 | 0 | 0 | 0 | 0 | 22409 | 0 | 0 | 0 | 0 | 0 | 22409 |
| 1968 | 0 | 0 | 0 | 0 | 14395 | 0 | 0 | 243 | 0 | 0 | 14638 |
| 1969 | 0 | 0 | 0 | 0 | 45965 | 0 | 0 | 891 | 0 | 0 | 45956 |
| 1970 | 0 | 0 | 0 | 0 | 12080 | 0 | 0 | 703 | 0 | 0 | 12783 |
| 1971 | 0 | 0 | 0 | 159 | 72704 | 590 | 0 | 600 | 0 | 0 | 73853 |
| 1972 | 0 | 0 | 0 | 7613 | 96071 | 3628 | 0 | 119 | 0 | 0 | 105431 |
| 1973 | 0 | 0 | 0 | 5963 | 90133 | 32965 | 0 | 54 | 0 | 0 | 129135 |
| 1974 | 0 | 0 | 0 | 18886 | 141227 | 4341 | 0 | 324 | 0 | 0 | 164778 |
| 1975 | 140 | 0 | 0 | 14133 | 90728 | 942 | 0 | 54 | 0 | 0 | 106003 |
| 1976 | 0 | 0 | 0 | 8884 | 91951 | 1490 | 0 | 64 | 0 | 0 | 102307 |
| 1977 | 0 | 0 | 0 | 40957 | 118361 | 2884 | 0 | 999 | 41 | 0 | 162442 |
| 1978 | 0 | 0 | 0 | 24184 | 81918 | 2516 | 0 | 189 | 0 | 0 | 116727 |
| 1979 | 0 | 0 | 0 | 11459 | 152720 | 0 | 0 | 0 | 0 | 0 | 164179 |
| 1980 | 660 | 0 | 0 | 15879 | 54249 | 245 | 0 | 67 | 0 | 0 | 70360 |
| 1981 | 1679 | 0 | 0 | 11812 | 149979 | 0 | 0 | 63 | 0 | 0 | 163732 |
| 1982 | 0 | 0 | 0 | 39850 | 67835 | 480 | 0 | 80 | 0 | 0 | 107245 |
| 1983 | 0 | 0 | 0 | 6169 | 81211 | 4928 | 0 | 54 | 0 | 0 | 94374 |
| 1984 | 247 | 0 | 0 | 6786 | 29916 | 963 | 0 | 243 | 0 | 0 | 37795 |
| 1985 | 308 | 0 | 0 | 28690 | 67066 | 0 | 0 | 243 | 0 | 0 | 80319 |
| 1986 | 7008 | 0 | 0 | 18954 | 22550 | 176 | 0 | 40 | 0 | 0 | 40720 |
| 1987 | 0 | 0 | 0 | 10655 | 84488 | 0 | 0 | 281 | 0 | 0 | 95344 |
| 1988 | 0 | 0 | 0 | 2459 | 38761 | 220 | 0 | 946 | 0 | 0 | 42366 |
| 1989 | 0 | 0 | 130748 | 5727 | 63509 | 748 | 0 | 914 | 0 | 0 | 201718 |
| 1990 | 0 | 0 | 0 | 2829 | 32439 | 0 | 0 | 596 | 0 | 0 | 35864 |
| 1991 | 0 | 80380 | 15380 | 3823 | 37688 | 36 | 0 | 119 | 0 | 0 | 145186 |
| 1992 | 0 | 42630 | 103990 | 8287 | 74613 | 0 | 0 | 134 | 0 | 0 | 229254 |
| 1993 | 0 | 4634 | 10620 | 13261 | 57989 | 0 | 0 | 0 | 0 | 0 | 114240 |
| 1994 | 0 | 3020 | 0 | 9367 | 68303 | 989 | 0 | 194 | 0 | 0 | 82673 |
| 1995 | 0 | 24660 | 0 | 28968 | 56721 | 0 | 0 | 290 | 0 | 0 | 102551 |
| 1996 | 0 | 15290 | 20880 | 8799 | 98188 | 0 | 0 | 306 | 0 | 0 | 150503 |
| 1997 | 7078 | 0 | 0 | 9478 | 103815 | 0 | 0 | 385 | 0 | 0 | 120540 |
| 1998 | 0 | 840 | 11268 | 21611 | 84538 | 0 | 0 | 180 | 0 | 0 | 123009 |
| 1999 | 0 | 0 | 40570 | 11389 | 80225 | 0 | 0 | 184 | 0 | 0 | 140388 |
| 2000 | 0 | 28980 | 9710 | 11627 | 92936 | 0 | 0 | 264 | 0 | 0 | 142837 |
| 2001 | 0 | 0 | 25660 | 4838 | 65678 | 0 | 0 | 1 | 0 | 0 | 95377 |
| 2002 | 0 | 3660 | 0 | 7883 | 38836 | 0 | 0 | 26 | 0 | 0 | 48498 |
| 2003 | 0 | 0 | 0 | 3758 | 31628 | 0 | 0 | 424 | 0 | 0 | 35802 |
| 2004 | 6 | 26700 | 0 | 1726 | 26158 | 0 | 0 | 279 | 0 | 0 | 28655 |
| 2005 | 0 | 0 | 16980 | 1915 | 11688 | 0 | 0 | 0 | 0 | 0 | 28615 |
| TOTALS | 17962 | 250310 | 406370 | 420712 | 3866103 | 60869 | 0 | 33588 | 1035 | 0 | 4366940 |

SOURCE: CPA Statistical Handbook

**Footnotes**

[1]Fields included by the CPA were: Jumping Pound West, Bonnie Glen, Waterton and Judy Creek.

[2]ERCB Report 85-A. This report provides a thorough analysis of oil reserves in Alberta.

# Chapter 7

# CONCLUSION

## 7.1 Estimations

This report is intended to assist policy makers, students and researchers in understanding the processes and data involved in reserves estimations in Alberta. Some important aspects of this review are summarized below.

This report has presented a review of the basic technology of reserves estimation. The methodologies differ for oil and gas and become more complex as different recovery mechanisms are employed. This review was intended to provide a basic understanding of the geological and engineering processes which are performed during reserves estimations. In addition to a technical review, an assessment of the limitations and strengths of these methods is presented in Chapter 3. Here we note that estimates tend to be more accurate as more information and production have been obtained from each pool. There are many different approaches to presenting the information once it has been technically obtained.

**We propose that the established reserves definition is a superior method of presenting reserves data for policy making purposes, despite overtures in the United States suggesting that a more conservative definition be used.**

The World Petroleum Congress and other professional associations in the U.S.[1] are proposing that a world standardized definition for reserves be adopted using a "proved reserves" definition. They suggest that the definition be based upon the current day oil price and economic conditions. Such a definition is similar to the Proved Reserves (WPC) definition outlined in Chapter 3. As noted in Chapter 3, such a definition seems inferior to established reserves as a policy tool because the definition of Established Reserves allows for long term fluctuations in price. In light of the recent large fluctuations in crude oil prices, the Established Reserves definition not only provides a "best estimate" of reserves but it also prevents continual

adjustments to reserves which would be based only on daily economic changes.

In acknowledgement of this, the American Gas Association has recently been considering adopting "established reserves" as a working definition within its organization.

In Chapters 4 and 5, the CPA and ERCB internal reserves estimation procedures were described. These procedures are reflected in the presentation format of the data and in the estimates themselves. A major difference between the organizations' procedures is the treatment of the booking of reserves. As a regulatory agency the ERCB tends to be more conservative than the CPA. However the CPA can attempt to estimate reserves as a "best estimate" without regulatory constraints.

There are some presentation inconsistencies which could be improved upon. It is unfortunate that the ERCB does not continue to publish oil reserves by year of discovery. **It would be useful to researchers to have the published ERCB data for oil reserves classed by year of discovery.**

It is also unfortunate that both organizations have decided not to publish adjustments separately from extensions or additions. Future analysis of development and exploration reserves and corresponding drilling activities will be very difficult without such separate data. Because reserves are presented only as estimates, it is important to have as much data surrounding those estimates as possible in order to help the researcher gauge reasonable errors in the data.

**Therefore we propose that the ERCB and CPA reconsider publishing and/or collecting data on the basis of adjustments separate from other additions categories.**

## 7.2 Summary of Results

In comparison to almost anywhere else in the world, Alberta has available the most complete and thorough reserves statistics. The ERCB has dedicated tremendous resources in order to make accurate measurements and assessments of the Province's reserves and potential. The CPA has consistently estimated reserves using intimate knowledge and understanding of Alberta's hydrocarbon reserves.

Alberta benefits from having two assessments of reserves. Reserves estimates are only approximate and it is better to have two independent organizations attempting to make these estimates, given the many different areas where errors or mis-estimations can take place.

The estimates provided by the ERCB and CPA both have tremendous value for policy planning and allocation purposes. As brought out earlier in the paper, the ERCB publishes detailed reports for all areas where established reserves exist in Alberta. The CPA publishes many different presentations of its estimates, giving the researcher greater flexibility in the approach to analysis.

Historically the CPA estimates of oil have been higher than those of the ERCB, but recently these differences have faded. The CPA is now using ERCB data for the smaller pools in both the oil and gas estimates. Recently, this has had the effect of raising the CPA estimates of Established Reserves of Marketable Gas. Estimates of larger pools, which account for over 80% of the entire reserves base, are still carried out independent of the ERCB.

The comparisons of New Additions of oil and gas, presented in Chapter 6, give an overview of the trends in historical estimates.

Estimates of Oil Sands reserves were also compared in Chapter 6. The mining reserves estimates showed very little difference and the differences basically came from different estimates of initial established reserves.

In-situ reserves estimates have differed and still differ substantially. In 1984 the CPA estimate was much lower than that of the ERCB; in 1985 the CPA estimate was double that of the ERCB. These estimates are in a developmental stage and it may take several years until some consistency is introduced into the methodology of the two organizations.

Other major differences in estimates were demonstrated in the Natural Gas Liquids section. The ERCB estimates seemed to be greater at first glance; however, after a reconciliation was made of the reserves included by each group, the CPA estimates which were included were greater than the ERCB estimates. The ERCB includes in its numbers natural gas liquids recovered by reprocessing plants and thereby includes many more pools in the ethane reserves estimates. We propose that the ERCB and CPA present reserves estimates on Propane,

**Butanes, Ethane and Pentanes Plus in a format which can be easily compared.** Pentanes Plus, presented separately, were not significantly different, nor were estimates of Sulphur reserves.

There seem to be two general areas in which additional work might be undertaken by the ERCB and CPA to standardize their approaches. Clearly the analysis of Natural Gas Liquids, particularly the presentation methodologies of Propane, Butanes and Ethane reserves, needs more co-ordination. Also, the reserves of In-situ oil are likely to develop further in the light of rapidly changing economic conditions. Attention could be focused on these reserves estimates by both the CPA and ERCB.

**Footnotes**

[1]Proved Reserve Definitions, Society of Petroleum Engineers of AIME, 1981, Dallas, Texas.

# APPENDIX A

## JOINT TASK FORCE ON UNIFORM RESERVES TERMINOLOGY
## NOVEMBER 1978

## Appendix A

### JOINT TASK FORCE ON UNIFORM RESERVES TERMINOLOGY NOVEMBER 1978

Appendix A is the report of the Joint Task Force on Uniform Reserves Terminology, November 1978. This task force was comprised of representatives from the Provinces of British Columbia, Alberta, and Saskatchewan, the National Energy Board, the Independent Petroleum Association of Canada and the Canadian Petroleum Association. The results of this task force have been generally accepted by the participants and others and have been used since November 1978.

The report includes definitions of Established Reserves and Ultimate Potential, among many others.

# REPORT OF

# JOINT TASK FORCE ON UNIFORM RESERVES TERMINOLOGY

# NOVEMBER 1978

## Introduction

This Task Force was formed under the auspices of the Inter-Provincial Advisory Committee on Energy (IPACE) to develop uniform terminology and definitions for use in estimating and publishing hydrocarbon reserves in Canada. The first meeting of the Task Force was held on August 3, 1978, and the assignment was completed on November 2, 1978. This report presents the results of the Task Force efforts.

The need for uniform reserves terminology and definitions has been recognized for some time. In recent years there has been great confusion about the extent of Canada's hydrocarbon reserves because of the multitude of terms and definitions employed. At the September 1977 Conference of the Provincial Ministers of Mines, The Canadian Petroleum Association proposed the formation of a task force to deal with the problem, and the Joint Task Force on Uniform Reserves Terminology was later formed for this purpose. The Task Force consisted of representatives of the provinces of British Columbia, Alberta and Saskatchewan; the National Energy Board; the Canadian Petroleum Association and the Independent Petroleum Association of Canada. Attachment 1 is a list of the Task Force members.

## Recommendations

The Task Force recommends the adoption of the list of reserves terms and definitions presented in Attachment 2 of this report. The major reserves terms are illustrated graphically in Figures 1 and 2.

The Task Force urges the inclusion of the relevant definitions in any publication of Canadian reserves by government agencies, industry associations, companies or individuals. Adoption of uniform terminology and definitions for reserves will help bring about a better understanding of published reserves estimates and also improve the comparability of such estimates.

The Task Force recommends these terms and definitions be published under the auspices of the Council of Energy Ministers, and that appropriate publicity be given to them by the issuing of a press release and by distribution to government, industry and other interested parties.

## Impact of Recommendations

It is expected that there will be little if any change in the level of Canadian reserves of oil, gas and gas products published by Provincial, Federal and Industry estimators as a result of the adoption of the recommended terms and definitions set out in this report. The following compares the current terminology of the major Canadian reserves estimators with the recommended term "Established Reserves":

| Estimator | Current Reserves Term |
|---|---|
| British Columbia Ministry of Mines and Petroleum Resources | Established |
| Alberta Energy Resources Conservation Board | Proved |
| Saskatchewan Department of Mineral Resources | Proven plus Probable |
| National Energy Board | Established |
| Canadian Petroleum Association | Probable |

Although there are some differences in the currently used reserves terms, the definitions used by all the listed reserves sources are essentially the same and correspond closely with the recommended definition of Established Reserves.

ATTACHMENT 1

JOINT TASK FORCE ON
UNIFORM RESERVES TERMINOLOGY

A. G. T. (Bill) Weaver
Chief Engineer, Engineering Division
Petroleum Resources Branch
Ministry of Mines and Petroleum Resources
Victoria, British Columbia V8V 1X4
Representing: Province of British Columbia

G. A. (George) Warne
Technical Assistant to the Chairman
Energy Resources Conservation Board
603 - Sixth Avenue, S.W., Calgary, Alberta T2P 0T4
Representing: Province of Alberta

R. H. (Ray) Knudsen
Chief Engineer, Petroleum and Natural Gas Branch
Department of Mineral Resources
1414 Hamilton Street, Regina, Saskatchewan S4P 4V4
Representing: Province of Saskatchewan

W. A. (Al) Hiles
Chief Reserves Division
Energy Resources Branch
National Energy Board
Trebla Building, 473 Albert Street, Ottawa, Ontario K1A 0E5
Representing: National Energy Board
(alternate C.H. (Cliff) Gemeroy)

G. C. (Gerry) Knutson
(alternate R. E. (Ralph) Hughes)
McDaniel Consultants (1965) Ltd.
400, 640 - Seventh Avenue S.W., Calgary, Alberta T2P 0Y5
Representing: Independent Petroleum Association of Canada

H. S. (Harry) Simpson (Task Force Chairman)
Vice-Chairman, CPA Reserves Committee
Esso Resources Canada Limited
500 - Sixth Avenue S.W., Calgary, Alberta T2P 0S1
Representing: Canadian Petroleum Association

ATTACHMENT 2

## RECOMMENDED RESERVES TERMINOLOGY AND DEFINITIONS

### INITIAL VOLUME IN-PLACE

The gross volume of Crude Oil, Crude Bitumen or Raw Natural Gas calculated or interpreted to exist in a reservoir before any volume has been produced.

### ESTABLISHED RESERVES

Those reserves recoverable under current technology and present and anticipated economic conditions, specifically proved by drilling, testing or production, plus that judgement portion of contiguous recoverable reserves that are interpreted to exist, from geological, geophysical or similar information, with reasonable certainty.

### INITIAL ESTABLISHED RESERVES

Established Reserves prior to the deduction of any production.

### REMAINING ESTABLISHED RESERVES

Initial Established Reserves less cumulative production.

### ULTIMATE POTENTIAL

An estimate of the Initial Established Reserves which will have become developed in an area by the time all exploratory and development activity has ceased, having regard for the geological prospects of that area and anticipated technology and economic conditions. Ultimate Potential includes cumulative production, Remaining Established Reserves and future additions through extensions and revisions to existing pools and the discovery of new pools.

### PRIMARY RECOVERY

The volume of Crude Oil and Natural Gas recoverable by natural depletion processes only.

### SECONDARY RECOVERY

The incremental volume of Crude Oil and Natural Gas recoverable by conventional water flooding, pressure maintenance or cycling.

### TERTIARY RECOVERY

The incremental volume of Crude Oil and Natural Gas recoverable by a process after or in lieu of conventional water flooding, pressure maintenance or cycling. A Tertiary Recovery process may be implemented without a preceding Secondary Recovery scheme.

ENHANCED RECOVERY

A general term for the incremental volume of Crude Oil and Natural Gas recoverable over the volume recoverable by natural depletion processes only. Enhanced Recovery is the sum of secondary and tertiary recovery.

CRUDE OIL

A mixture, consisting mainly of pentanes and heavier hydrocarbons that may contain sulphur compounds, that is liquid at the conditions under which its volume is measured or estimated, but excluding such liquids obtained from the processing of natural gas.

CONVENTIONAL CRUDE OIL

Crude Oil recoverable through wells where production can initially be achieved at commercial rates without altering the natural viscous state of the oil. This includes subsequent production from such reservoirs by thermal methods and Crude Oil from certain pools from which production cannot initially be achieved at commercial rates, but which, for other reasons, are designated as Conventional Crude Oil.

NON-CONVENTIONAL CRUDE OIL

Crude Oil other than Conventional Crude Oil.

CRUDE BITUMEN

A naturally occurring viscous mixture, mainly of hydrocarbons heavier than pentane, that may contain sulphur compounds and other minerals and that in its natural viscous state is not recoverable at a commercial rate through a well.

SYNTHETIC CRUDE OIL

Crude Oil derived from the upgrading of Crude Bitumen or by chemical modification of coal or other materials and which is largely interchangeable with Conventional Crude Oil as a refinery feedstock.

RAW NATURAL GAS

The lighter hydrocarbons and associated non-hydrocarbon substances occurring naturally in an underground reservoir, which under atmospheric conditions is essentially a gas, but which may contain liquids.

MARKETABLE NATURAL GAS ~~RESERVES~~

Natural Gas which is available to a transmission line after removal of certain hydrocarbons and non-hydrocarbon compounds present in the Raw Natural Gas and which meets specifications for use as a domestic, commercial or industrial fuel. Marketable Natural Gas excludes field and plant fuel and losses, excepting those related to downstream reprocessing plants.

NON-ASSOCIATED GAS

Natural Gas not in contact with Crude Oil in the reservoir or Natural Gas in contact with Crude Oil where the volume of oil is small and where production of such gas does not significantly affect the Crude Oil recovery.

ASSOCIATED GAS

Natural Gas, commonly known as gas-cap gas, which overlies and is in contact with Crude Oil in the reservoir, except where the volume of oil is small and where production of such gas does not significantly affect the Crude Oil recovery.

SOLUTION GAS

Natural Gas which is in solution with Crude Oil in the reservoir at original reservoir conditions and which is normally produced with the Crude Oil.

NATURAL GAS LIQUIDS

Natural Gas Liquids are those hydrocarbon components recovered from Raw Natural Gas as liquids by processing through extraction plants or recovered from field separators, scrubbers or other gathering facilities. These liquids include the hydrocarbon components ethane, propane, butanes and pentanes plus, or a combination thereof.

CONDENSATE

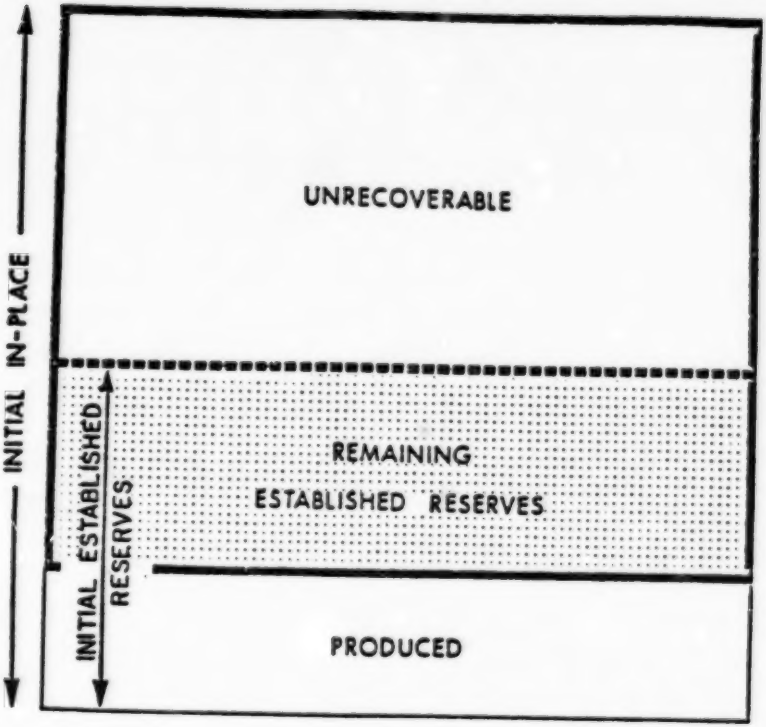
A mixture composed mainly of pentanes and heavier hydrocarbons recovered as a liquid from field separators, scrubbers or other gathering facilities before the gas is processed in a plant.

PENTANES PLUS

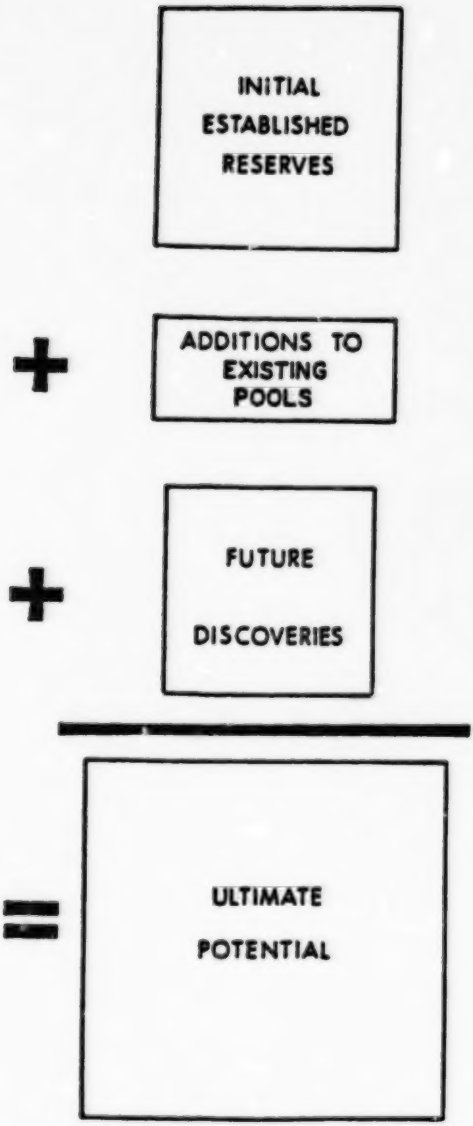
A mixture mainly of pentanes and heavier hydrocarbons which ordinarily may contain some butanes and which is obtained from the processing of raw gas, condensate or crude oil, or from marketable gas processed in a downstream reprocessing plant.

LIQUIFIED PETROLEUM GASES (LPG)

Liquified Petroleum Gases consist primarily of the hydrocarbon components propane or butanes, or a combination thereof.




SCHEMATIC REPRESENTATION OF INITIAL AND
REMAINING ESTABLISHED RESERVES




COMPONENTS OF ULTIMATE POTENTIAL

# APPENDIX B

## NATIONAL POLICY NO. 2-B

## GUIDE FOR ENGINEERS AND GEOLOGISTS SUBMITTING OIL AND GAS REPORTS TO CANADIAN PROVINCIAL SECURITIES ADMINISTRATORS

## Appendix B

## NATIONAL POLICY No. 2-B

## GUIDE FOR ENGINEERS AND GEOLOGISTS SUBMITTING OIL AND GAS REPORTS TO CANADIAN PROVINCIAL SECURITIES ADMINISTRATORS

Appendix B contains the National Policy No. 2-B as published by the Ontario Securities Commission. National Policy No. 2-B covers the content of oil and gas reports, including definitions and presentation of reserves information. A National Policy is a policy designed by Canadian Provincial Securities Commissions pertaining to national distribution of public stock. Since securities regulation is within provincial jurisdiction, a national policy must be adopted by each province to be effective. Alberta has adopted National Policy No. 2-B.

These definitions of proved reserves can be compared to those of "Established Reserves" provided in Appendix A.

## NATIONAL POLICY No. 2-B

## GUIDE FOR ENGINEERS AND GEOLOGISTS SUBMITTING OIL AND GAS REPORTS TO CANADIAN PROVINCIAL SECURITIES ADMINISTRATORS

*GENERAL*

1. Reports submitted must be engineering documents. They must be factual, and any recommendations must be warranted in light of the information and data presented in the report. If the report contains recommendations, the author must state that, in his judgement, the venture is of sufficient merit to make the work recommended a worthwhile undertaking.
2. If any information and data in an engineering report are not based on the author's own observations and investigations, their source shall be clearly stated, reference shall be made to reports and records from which the information and data was obtained, and the author shall state the degree of reliance he has placed on such reports and records. When information is derived from unpublished or private reports or records, a letter of consent from, and a certificate of qualification of, the author of such reports or records shall be submitted.
3. Reports will be accepted only if prepared by a registered professional engineer or a registered professional geologist who is a member in good standing of an appropriate association of professional engineers or geologists, unless he holds exceptional qualifications and there are unusual circumstances.
4. With reference to item 4.1.5, if principals in the independent consulting firm which prepared the report have or will acquire direct or indirect interests in properties or securities of the issuer or any associate or affiliate of the issuer, such interests must be clearly disclosed in the report.
5. Although Appendix 2 lists certain material in engineering reports which shall be included in a prospectus, the issuer may include additional disclosure and staff of the Securities Commissions may require additional material or disclosure to be included in a prospectus.
6. Reports shall be prepared only by a registered professional engineer or a registered professional geologist who is independent of the issuer or any associate or affiliate of the issuer. Therefore, reports shall not be written by a director, officer or employee of the issuer or any associate or affiliate of the issuer or by any person or company associated with such director, officer or employee. Notwithstanding the foregoing, in-house reports may be accepted at the discretion of the Director of the Securities Commission, but only from large well established issuers.

## National Policy No. 2-B

*CONTENT OF OIL AND GAS REPORTS*

A complete engineering and geological report for submission to Canadian Provincial Securities Administrators shall include the following material:

1. TABLE OF CONTENTS

2. INTRODUCTION

2.1 Author's terms of reference. State whether the report was prepared specifically for the purpose of submission to Securities Administrators or whether it will serve other purposes as well.

2.2 Names of principal properties. Include all major properties (including all properties to which the proceeds of issue are being applied) and identify them by the commonly referred to field or area names and disclose the jurisdiction (province, state, etc.). Briefly describe and discuss the geology of the properties. Discussion of geographic factors such as climate and accessibility need be included only in special situations such as frontier resources.

2.3 Summary of estimated net reserves and corresponding values.

2.3.1 Proved reserves and dollar values on a net cash-flow basis. Dollar values shall be calculated at current prices and costs, unless under contract as to price, to all future time. Additonally dollar values may be presented based on forecast prices and costs but critical assumptions in such a forecast shall be stated. Net cash-flow values shall be presented at discount rates of 0%, 10%, 15% and 20%.

2.3.2 Probable additional reserves and dollar values on a net cash-flow basis. Dollar values shall be calculated at current prices and costs, unless under contract as to price, to all future time. Additionally, dollar values may be presented based on forecast prices and costs but critical assumptions in such a forecast shall be stated. Net cash-flow values shall be presented at discount rates of 0%, 10%, 15% and 20%. Also, probable additional reserves shall be reduced for an allowance for the risk that is associated with the probability of obtaining production from such rserves.

2.3.3 A statement that the values reported under 2.3.1 and 2.3.2 may not necessarily be the fair market value of the reserves.

2.3.4 A statement as to whether the values are before or after income tax.

2.4 The percentage and quantity of proved producing reserves which are currently on production. (See definition 6 of Appendix 1.)

2.5 Definitions employed shall be the same as those listed in Appendix 1 and any deviation shall be stated along with supporting reasons.

2.6 Discussion of methods employed. Identify the methods used to estimate reserves and production rates and to convert them to cash flows. Include any assumptions respecting the availability of markets.

2.7 Discussion and identification of risk factors used, particularly respecting probable additional reserves, and justification for their selection.

2.8 Acceptable disclaimer. State clearly any conditions respecting the responsibility of the author. For example, the author might indicate that all estimated reserve quantities were based on geological and engineering data provided by the issuer although the interpretation of the data was carried out by the author, and might state whether or not he has grounds for a judgement that the data are sound. He shall also state whether he made an on-site visit of the properties and, if not, state briefly the reasons why a visit was judged unnecessary.

2.9 Where proceeds of the issue are to be expended on drilling on a specified property(ies), the report shall contain recommendations, conclusions and cost estimates in respect of the proposed drilling. Where appropriate, the author shall discuss the results of prior drilling on the property and on adjoining or nearby areas.

2.10 Summary of undeveloped gross and net acreage and value assigned to net acreage.

2.11 Signature and professional seal or permit stamp of author.

3. SUPPORTING MATERIAL

3.1 Listings of properties shall include, but not be limited to, the following:

3.1.1 jurisdictions and location therein, and names of fields and areas including an index map(s)

3.1.2 Detail maps showing —

3.1.2.1 the issuer's interest lands and the issuer's interest in them

3.1.2.2 wells in which the issuer has an interest and wells of others together with their status.

3.1.3 Brief descriptions of the geology of the issuer's properties.

3.1.4 Tabulations of reservoir rock and fluid parameters for each well or pool including, but not limited to, depth of each pay zone, its porosity, pay zone thickness (specify gross or net), water saturation, pressure, temperature, recovery factor, etc.

3.1.5 Types of reserves* assigned:

3.1.5.1 crude oil

3.1.5.2 synthetic oil, or bitumen and corresponding synthetic oil yield factor

3.1.5.3 natural gas

3.1.5.4 natural gas liquids

3.1.5.5 sulphur.

* Reserves assigned to "tight-hole" or confidential (by law) areas may be grouped and published as part of the listing as reserves only. Alternatively, if they are not included in the reserves listing, there shall be appropriate discussion describing the method of handling such properties.

3.1.6 Status of reserve assigned:

3.1.6.1 proved or probable additional.

3.1.6.2 proved producing or proved non-producing.

3.1.7 Company interest:

3.1.7.1 gross share of reserves before royalties

3.1.7.2 applicable royalties and/or production payments

3.1.7.3 net share of reserves after royalties.

3.1.8 Quantity of reserve assigned:

3.1.8.1 proved producing, proved non-producing, and total proved

3.1.8.2 probable additional

3.1.8.3 total

3.1.9 Forecast of future net production, revenue, costs and net cash flow on a proved producing, proved non-producing, and total proved reserve basis and on a probable additional reserve basis, by jurisdiction (province, state, etc.), and in total. Dollar values shall be calculated at current prices and costs, unless under contract as to price, to all future time. Additionally, dollar values may be presented based on forecast prices and costs but critical assumptions in such a forecast shall be stated. Net cash flow values shall be presented at discount rates of 0%, 10%, 15% and 20%. Also, probable additional reserves shall be reduced for an allowance for risk that is associated with the probability of obtaining production from such reserves.

3.2 A summary table itemizing the following basic assumptions, where applicable:

3.2.1 crude oil and synthetic oil price forecasts by jurisdiction

3.2.2 natural gas price forecast by jurisdiction

3.2.3 natural gas products price forecasts by jurisdiction

3.2.4 capital and operating costs

3.2.5 forecasts of inflation used respecting capital and operating costs

3.2.6 forecasts of any other factors employed on a general basis (e.g. crown royalty scale if different from those existing as of the effective date of the study).

3.2.7 Details of undeveloped acreage (both gross and net) disclosing field or area name, jurisdiction, value assigned to each separate net acreage, and method of determining those values.

3.2.8 Where proceeds of the issue are to be expended on drilling on a specified property(ies), the report shall contain recommendations, conclusions and cost estimates in respect of the proposed drilling. Where appropriate, the author shall discuss the results of prior drilling on the property and on adjoining or nearby areas.

4. CERTIFICATE OF AUTHOR

4.1 All reports must be submitted in duplicate with the author's certificate attached, both dated and signed. The certificate must contain the professional seal or permit stamp of the author and shall state:

4.1.1 the name, address and occupation of the author

4.1.2 the qualifications of the author

4.1.3 any conditions respecting the responsibility of the author and whether or not an on-site visit of the properties was made. If a visit was not made, state briefly why a visit was judged unnecessary.

4.1.4 the period during which the report was prepared and the effective date of the information therein.

4.1.5 whether or not the author has or expects to receive any interest, direct or indirect, in the properties or securities of the issuer or any associate or affiliate of the issuer and, if so, the particulars of the interest or beneficial ownership.

5. LETTER OF CONSENT

5.1 The letter shall be addressed to the Securities Commissions and shall include a description of the report from which the engineer or geologist is giving his consent from the inclusion of extracts in a prospectus or other document. It shall state the date of the report as well as the date of the prospectus, and shall contain a statement that he has read the prospectus and has no reason to believe that there are any misrepresentations in the information contained in it that is derived from his report or that is within his knowledge as a result of his employment.

*EFFECTIVE DATE:*

This policy comes into effect on 15 December 1982.

*Appendix 1.*

*DEFINITIONS*

1. CRUDE OIL: A mixture, consisting mainly of pentanes and heavier hydrocarbons that may contain sulphur compounds, that is liquid at the conditions under which its volume is measured or estimated, but excluding such liquids obtained from the processing of natural gas.

2. SYNTHETIC OIL: Oil derived from the upgrading of crude bitumen or by chemical modification of coal or other materials and which is largely interchangeable with conventional crude oil as a refinery feedstock.
3. NATURAL GAS: The lighter hydrocarbons and associated non-hydrocarbon substances occurring naturally in an underground reservoir, which under atmospheric conditions is essentially a gas, but which may contain liquids. The natural gas reserve estimates should be reported on a marketable basis, that is the gas which is available to a transmission line after removal of certain hydrocarbons and non-hydrocarbon compounds present in the raw natural gas and which meets specifications for use as a domestic, commercial or industrial fuel.
4. NATURAL GAS LIQUIDS: Those hydrocarbon components recovered from raw natural gas as liquids by processing through extraction plants or recovered from field separators, scrubbers or other gathering facilities. These liquids include the hydrocarbon components ethane, propane, butanes and pentanes plus, or a combination thereof.
5. PROVED RESERVES*: Those reserves estimated as recoverable under current technology and existing economic conditions, from that portion of a reservoir which can be reasonably evaluated as economically productive on the basis of analysis of drilling, geological, geophysical and engineering data, including the reserves to be obtained by enhanced recovery processes demonstrated to be economic and technically successful in the subject reservoir.
   * Where reserves are clearly known to exist in a reservoir and would be physically recoverable but cannot be termed "proved reserves" because they are not commercially recoverable due to their remote location (i.e., frontier reserves), these reserves should be itemized separately in the report and their special circumstances should be fully explained.
6. PROVED PRODUCING RESERVES: Those proved reserves that are actually on production or, if not producing, that could be recovered from existing wells or facilities and where the reasons for the current non-producing status is the choice of the owner rather than the lack of markets or some other reasons. An illustration of such a situation is where a well or zone is capable but is shut-in because its deliverability is not required to meet contract commitments.
7. PROVED NON-PRODUCING RESERVES: Those proved reserves that are not currently producing either due to lack of facilities and/or markets.
8. PROBABLE ADDITIONAL RESERVES: Those reserves which analysis of drilling, geological, geophysical and engineering data does not demonstrate to be proved under current technology and existing economic conditions, but where such analysis suggests the likelihood of their existence and future recovery. Probable additional reserves to be obtained by the application of enhanced recovery processes will be the increased recovery over and above that estimated in the proved category which can be realistically estimated for the pool on the basis of enhanced recovery processes which can be reasonably expected to be instituted in the future.

*Appendix 2.*

### *CERTAIN MATERIAL FROM OR RELATED TO ENGINEERING REPORTS WHICH SHALL BE INCLUDED IN A PROSPECTUS*

1. A summary of the estimated net reserves of the issuer with the following detail:

1.1 Reserves by jurisdiction and category (proved, proved producing, proved non-producing, probable additional) and type (crude oil, synthetic oil, natural gas, natural gas liquids, sulphur).

1.2 The values assigned to the above reserves on a net cash-flow basis, using discount rates of 0%, 10%, 15% and 20%. Values assigned must be based on prices and costs outlined in item 3.1.9 and disclosure shall be made in the prospectus of prices and costs used.

## National Policy No. 3

1.2.1 Estimated total capital costs necessary to achieve the net cash flow, and the amount of such costs estimated to be incurred in each of the first two years of the cash flow estimate.

1.3 A statement in bold print that the values reported under 1.2 may not necessarily be the fair market value of the reserves.

1.4 A statement in bold print as to whether the values are before or after income tax. Disclose the values on an after tax basis, if available.

1.5 The percentage and quantity of proved producing reserves which are currently on production. (See definition 6 of Appendix 1.)

2. A statement disclosing the source of data used in the estimates, including any comments the author of the engineering report might have respecting the soundness of the data.

3. A list of definitions employed.

4. A statement regarding the degree of risk assigned to values, particularly of probable additional reserves including a statement in bold print disclosing the approximate amount, or alternatively the approximate average percentage, by which the volume of probable reserves or their values have been reduced to allow for the risk associated with obtaining production from probable reserves. Where the author has not used percentages or calculated amounts as contemplated in the preceding sentence, a statement in bold print describing the method otherwise employed to allow for such risk.

5. A summary table of the assumptions employed regarding prices, costs, inflation and other forecast factors used.

6. Names of principal properties in which the issuer has an interest, identified by the commonly referred to field or area names and by jurisdiction (province, state, etc.).

7. A summary of undeveloped gross and net acreage by jurisdiction, and value assigned to undeveloped net acreage.

8. Where proceeds of the issue are to be expended on drilling on a specified property(ies), the author's recommendations, conclusions and cost estimates in respect of the proposed drilling.

9. Identification of the complete report, effective date thereof, name of author, and address at which the complete report is available for review.

# APPENDIX C

# ERCB OIL REVIEW

## Appendix C

## ERCB OIL REVIEW

The ERCB publishes and distributes the results of its year-end crude oil review and allows time for an operator to express disagreement with any proposed changes to oil reserves. Appendix C includes the covering letter generally sent out to operators and examples of the first pages of some attachments which accompany this letter.

ERCB

Energy Resources Conservation Board
640 Fifth Avenue SW
Calgary, Alberta
Canada T2P 3G4

# General Bulletin

GB 84-2

To: All Oil and Gas Operators

3 February 1984

## ANNUAL REVIEW OF CRUDE OIL RESERVES

For the 1983 year-end crude oil reserves review, the Oil Department staff reviewed the established reserve values for those crude oil pools where additional drilling had taken place or production data showed that a revision was necessary. As a result, the Board plans to amend its estimate of reserves for the pools as shown on Attachment I and to implement these revisions in the 1983 year-end reserves report. The reserve adjustments will be reflected for allowable purposes effective 1 May 1984.

If an operator disagrees with the initial established reserves as proposed in Attachment I, a letter of objection must be submitted on or before 15 March 1984 marked for the attention of A. R. Olive, Staff Specialist, Oil Department. Where an objection is received, the Board will not make the reserve change proposed by its staff, but rather will arrange a schedule for filing of an incremental reserves submission in accordance with Informational Letter IL-OG 76-23.

Listed in Attachment II are the oil pools which became non-confidential, resumed production, were redesignated, or were changed as a result of operator and Oil Department reservoir studies completed during 1983.

Listed in Attachment III are schemes which received enhanced recovery recognition during 1983 pursuant to applications for enhanced recovery schemes.

Listed in Attachment IV are enhanced recovery reserves established on the basis of applications for enhanced recovery schemes approved in 1983. These reserves are classified as "pre-booked" since they will not be assigned until the schemes are fully operational and have qualified for enhanced recovery status.

Inquiries concerning this letter may be directed to Mr. Alyn Olive, Oil Department, telephone 297-8555.

J. A. Bray, P.Eng.
Manager, Oil Department

Attachments

## ATTACHMENT 1

## PROPOSED RESERVE CHANGE

| Pool Light and Medium Crude Oil | Current Initial Vol. in Pl. $10^3m^3$ | Current Initial Est. Res. $10^3m^3$ | Proposed Initial Vol. in Pl. $10^3m^3$ | Proposed Initial Est. Res. $10^3m^3$ | Remarks** |
|---|---|---|---|---|---|
| Acheson Blairmore C* | 97.3 | 14.6 | 130.0 | 19.5 | Increase N - Np approaching RiN |
| Acheson Blairmore F | 183.0 | 18.3 | 183.0 | 0.1 | Pool Suspended - Set RiN = Np |
| Acheson Blairmore D&I* | 224.0 | 22.4 | 300.0 | 30.0 | Increase N - Np approaching RiN |
| Acheson D-2A* | 752.0 | 413.0 | 775.0 | 426.0 | Increase N - Np approaching RiN |
| Acheson East Blairmore A* | 472.0 | 118.0 | 492.0 | 123.0 | Increase N - Np approaching RiN |
| Aerial Viking A* | 275.0 | 5.5 | 275.0 | 0.6 | Pool Suspended - Set RiN = Np |
| Amber Muskeg B | 159.0 | 47.7 | 159.0 | 32.5 | Pool Suspended - Set RiN = Np |
| Battle Viking* | 710.0 | 178.0 | 824.0 | 206.0 | Increase N - New wells added |
| Battle South Viking* | 527.0 | 174.0 | 846.0 | 254.0 | Increase N - Decrease Ri - New wells added |
| Bashaw D-2A* | 992.0 | 19.9 | 992.0 | 22.0 | Increase Ri - Np approaching RiN |
| Bashaw D-3B* | 264.0 | 21.1 | 264.0 | 26.4 | Increase Ri - Np approaching RiN |
| Bellshill Lake Blairmore E | 1 790.0 | 179.0 | 1 790.0 | 53.7 | Decrease Ri - Performance |

* Pools Subject to Good Production Practice

** Abbreviations

- Ri - Recovery Factor
- Np - Cumulative Oil Production
- RiN - Recoverable Reserves
- N - Initial Volume in Place

## ATTACHMENT II

## NON-CONFIDENTIAL POOLS DECLARED OR REDESIGNATED AFTER 31 DECEMBER 1982

## AND

## OTHER POOLS FOR WHICH RESERVE DATA WERE CHANGED AFTER 31 DECEMBER 1982

### Initial Established Crude Oil Reserves

| Pool<br>Light and Medium Crude Oil | At 31 Dec. 1982<br>$10^3m^3$ | At 31 Dec. 1983<br>$10^3m^3$ | Change<br>$10^3m^3$ | Reason for Change |
|---|---|---|---|---|
| Acheson Blairmore F | 39.7 | 75.0 | +35.3 | Re-evaluation - Decreased N Increased Ri |
| Acheson Ellerslie A | undef | 34.3 | +34.3 | New Pool 1 January 1983 |
| Acheson Ellerslie B | 0.0 | 38.7 | +38.7 | New Pool 1 October 1983 |
| Acheson Wabamun A | conf | 91.7 | - | Lost confidential status 1 February 1983 |
| Acheson D-3A | 17 300.0 | 19 900.0 | +2 600.0 | Re-evaluation - Increased N Decreased Ri |
| Acheson East Blairmore B | 536.0 | 597.0 | +61.0 | Re-evaluation - Decreased N Increased Ri |
| Acheson East Blairmore C | 0.0 | 25.0 | -19.3 | Re-evaluation - Decreased N (previously Acheson Blairmore Q) |
| Acheson East Blairmore D | 0.0 | 60.0 | +60.0 | New Pool 1 September 1983 (previously part of Blairmore B Pool) |
| Aerial Mannville | | | | Re-evaluation - Primary |
| (primary) | 56.4 | 34.3 | -22.1 | tracts given Enhanced |
| (gas flood) | 201.0 | 238.0 | +37.0 | Recovery Recognition |
| Amber Muskeg C | undef | 38.7 | +38.7 | New Pool 1 January 1983 |
| Amber Keg River P | undef | 638.0 | +638.0 | New Pool 1 January 1983 |
| Amber Keg River Q | 0.0 | 158.0 | +158.0 | New Pool 1 March 1983 |
| Armada Upper Mannville A | undef | 72.4 | - | New Pool 1 May 1983 |

# APPENDIX D

## ALBERTA GAS RESERVE TRENDS, 31 DECEMBER, 1985

## Appendix D

## ALBERTA GAS RESERVE TRENDS, 31 DECEMBER, 1985

The ERCB published a paper in 1985 on trends in the growth of marketable gas reserves.[1] This valuable publication reviewed the major changes in gas reserves over the last 20 years. The publication also contained valuable data and graphs which are included as Appendix D.

The first table from the report (Table G-2) compares initial reserves of marketable gas and exploratory wells drilled. The second table (Table G-3) is an historical summary of the appreciation of reserves over time. The third table (Table G-4) provides an appreciation factor to initial reserves and analyzes it in relation to exploratory wells. The fourth table (Table G-5) presents marketed production and remaining reserves over time.

The graphs which are included in the ERCB report and duplicated here are quite useful. Figure G-1 shows the growth of initial established reserves of Marketable Gas. Figure G-2 shows how reserves discovered in particular years have appreciated over time. Figure G-3 is a graph of the average appreciation factor which is expected for Alberta Reserves of Marketable Gas. Figure G-4 compares the annual and cumulative appreciated reserves with the number of exploratory wells drilled each year.

---

[1]Publication number ERCB ST 86-47

TABLE G-2 SUMMARY OF STATISTICS OF EXPLORATORY DRILLING AND GROWTH OF INITIAL ESTABLISHED RESERVES OF MARKETABLE GAS
As at 31 December 1985

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Discovery Year | Exploratory Wells Drilled | | Initial Reserves of Marketable Gas | | Initial Reserves of Marketable Gas Per Exploratory Well | |
| | | | $10^6$ $m^3$ | | | |
| | Annual | Cumulative | Annual | Cumulative | Annual | Cumulative |
| Prior to 1947 | | 567[a] | | 402 278 | | 709 |
| 1947 | 71 | 638 | 23 518 | 425 796 | 331 | 667 |
| 1948 | 126 | 764 | 14 258 | 440 054 | 113 | 576 |
| 1949 | 209 | 973 | 44 975 | 485 029 | 215 | 498 |
| 1950 | 224 | 1 197 | 11 779 | 496 808 | 53 | 415 |
| 1951 | 461 | 1 658 | 77 740 | 574 548 | 169 | 347 |
| 1952 | 469 | 2 127 | 91 840 | 666 388 | 196 | 313 |
| 1953 | 399 | 2 526 | 88 473 | 754 861 | 222 | 299 |
| 1954 | 351 | 2 877 | 146 459 | 901 320 | 417 | 313 |
| 1955 | 346 | 3 223 | 88 202 | 989 522 | 255 | 307 |
| 1956 | 384 | 3 607 | 93 805 | 1 083 327 | 244 | 300 |
| 1957 | 428 | 4 035 | 110 810 | 1 194 137 | 259 | 296 |
| 1958 | 404 | 4 439 | 77 888 | 1 272 025 | 193 | 287 |
| 1959 | 432 | 4 871 | 140 578 | 1 412 603 | 325 | 290 |
| 1960 | 403 | 5 274 | 49 723 | 1 462 326 | 123 | 277 |
| 1961 | 423 | 5 697 | 133 657 | 1 595 983 | 316 | 280 |
| 1962 | 484 | 6 181 | 66 614 | 1 662 597 | 138 | 269 |
| 1963 | 502 | 6 683 | 72 804 | 1 735 401 | 145 | 260 |
| 1964 | 570 | 7 253 | 30 130 | 1 765 531 | 53 | 243 |
| 1965 | 705 | 7 958 | 61 996 | 1 827 527 | 88 | 230 |
| 1966 | 634 | 8 592 | 22 017 | 1 849 544 | 35 | 215 |
| 1967 | 693 | 9 285 | 79 933 | 1 929 477 | 115 | 208 |
| 1968 | 936 | 10 221 | 37 236 | 1 966 713 | 40 | 192 |
| 1969 | 972 | 11 193 | 64 505 | 2 031 218 | 66 | 181 |
| 1970 | 963 | 12 156 | 31 607 | 2 062 825 | 33 | 170 |
| 1971 | 940 | 13 096 | 37 704 | 2 100 529 | 40 | 160 |
| 1972 | 1 058 | 14 154 | 77 373 | 2 177 902 | 73 | 154 |
| 1973 | 1 543 | 15 697 | 56 343 | 2 244 772 | 37 | 143 |
| 1974 | 1 248 | 16 945 | 74 361 | 2 319 133 | 60 | 137 |
| 1975 | 1 238 | 18 183 | 45 402 | 2 364 535 | 37 | 130 |
| 1976 | 2 082 | 20 265 | 88 182 | 2 452 717 | 42 | 121 |
| 1977 | 2 317 | 22 582 | 106 085 | 2 558 802 | 46 | 113 |
| 1978 | 2 304 | 24 886 | 90 331 | 2 649 133 | 39 | 106 |
| 1979 | 1 888 | 26 774 | 87 314 | 2 736 447 | 46 | 102 |
| 1980 | 2 299 | 29 073 | 93 394 | 2 829 841 | 41 | 97 |
| 1981 | 2 008 | 31 081 | 65 678 | 2 895 519 | 33 | 93 |
| 1982 | 1 498 | 32 579 | 38 036 | 2 933 555 | 25 | 90 |
| 1983 | 1 177 | 33 756 | 31 628 | 2 965 183 | 27 | 88 |
| 1984 | 1 535 | 35 291 | 28 150 | 2 993 333 | 18 | 85 |
| 1985 | 1 587 | 36 878 | 11 600 | 3 004 933 | 7 | 81 |

a Estimated.

TABLE 0-3 HISTORICAL SUMMARY OF APPRECIATION OF INITIAL ESTABLISHED RESERVES OF MARKETABLE GAS
As at 31 December 1985
YEARS FROM END OF DISCOVERY YEAR
INITIAL RESERVES OF MARKETABLE GAS
MILLIONS OF CUBIC METRES

| Discovery Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 10 144 | 26 468 | 47 138 | 45 069 | 33 986 | 47 510 | 48 770 | 48 006 | 48 052 | 48 053 | 53 977 | 53 329 | 52 638 | 53 635 | 57 178 | 58 350 | 57 793 | 55 885 | 56 393 | 57 236 | 54 768 |
| 1952 | 13 565 | 21 192 | 27 899 | 29 183 | 35 347 | 40 059 | 46 463 | 47 083 | 47 629 | 51 503 | 55 843 | 59 514 | 62 289 | 65 442 | 63 367 | 66 334 | 68 502 | 69 759 | 69 759 | 69 561 | 70 954 |
| 1953 | 27 673 | 54 865 | 61 980 | 53 807 | 53 884 | 49 303 | 54 003 | 59 492 | 68 860 | 72 847 | 74 222 | 78 735 | 86 239 | 80 197 | 80 660 | 80 180 | 80 690 | 81 426 | 75 237 | 74 815 | 77 268 |
| 1954 | 12 880 | 24 228 | 61 563 | 67 584 | 99 221 | 111 500 | 130 616 | 126 932 | 133 711 | 133 289 | 134 450 | 137 514 | 136 445 | 137 157 | 137 890 | 134 465 | 125 117 | 126 594 | 128 354 | 136 914 | 136 372 |
| 1955 | 6 371 | 10 968 | 22 040 | 26 971 | 26 796 | 28 290 | 33 614 | 36 082 | 36 701 | 37 486 | 38 378 | 41 791 | 41 393 | 43 900 | 44 498 | 46 090 | 47 946 | 50 154 | 55 156 | 56 139 | 55 265 |
| 1956 | 11 053 | 16 396 | 22 510 | 23 830 | 38 604 | 41 538 | 46 026 | 48 039 | 54 158 | 56 094 | 56 825 | 58 401 | 60 034 | 61 026 | 61 311 | 64 656 | 65 026 | 69 883 | 70 531 | 67 432 | 68 111 |
| 1957 | 36 045 | 52 896 | 70 260 | 86 811 | 90 052 | 92 365 | 79 537 | 78 475 | 75 236 | 78 538 | 79 773 | 77 983 | 69 129 | 70 617 | 79 748 | 82 644 | 92 309 | 95 448 | 94 780 | 94 814 | 94 780 |
| 1958 | 37 352 | 53 004 | 62 875 | 61 550 | 70 265 | 69 963 | 69 546 | 66 328 | 64 537 | 68 562 | 68 895 | 72 725 | 72 378 | 73 545 | 78 752 | 77 279 | 77 862 | 75 310 | 76 741 | 77 855 | 78 358 |
| 1959 | 16 675 | 40 671 | 65 698 | 68 071 | 67 762 | 69 484 | 98 631 | 98 377 | 106 389 | 106 237 | 106 542 | 110 484 | 112 805 | 110 941 | 123 093 | 128 853 | 133 209 | 137 808 | 140 811 | 133 495 | 140 299 |
| 1960 | 17 831 | 32 664 | 23 683 | 24 775 | 30 877 | 38 037 | 44 736 | 46 227 | 46 950 | 46 840 | 46 674 | 43 579 | 41 448 | 42 812 | 43 121 | 38 849 | 39 113 | 40 242 | 40 733 | 40 425 | 41 199 |
| 1961 | 10 412 | 17 699 | 23 540 | 53 003 | 56 765 | 62 317 | 67 859 | 120 231 | 135 416 | 139 875 | 141 378 | 144 299 | 155 960 | 158 124 | 146 635 | 147 485 | 147 112 | 130 520 | 132 303 | 123 179 | 124 243 |
| 1962 | 9 358 | 31 983 | 44 446 | 45 330 | 53 990 | 59 327 | 59 300 | 60 706 | 61 746 | 63 477 | 63 987 | 64 619 | 64 682 | 61 821 | 60 805 | 60 936 | 61 586 | 61 933 | 61 395 | 56 462 | 57 163 |
| 1963 | 6 367 | 7 721 | 9 906 | 15 193 | 21 981 | 20 881 | 23 303 | 27 503 | 45 861 | 47 727 | 53 380 | 53 067 | 53 296 | 55 206 | 55 703 | 55 335 | 58 407 | 59 295 | 59 566 | 64 425 | 64 290 |
| 1964 | 3 497 | 17 737 | 16 586 | 13 230 | 13 357 | 13 526 | 13 868 | 12 206 | 12 038 | 16 970 | 16 826 | 14 640 | 15 122 | 17 097 | 18 611 | 18 111 | 18 845 | 19 018 | 19 312 | 20 063 | 20 217 |
| 1965 | 10 427 | 19 496 | 19 479 | 23 059 | 31 015 | 31 276 | 31 030 | 30 063 | 30 427 | 31 370 | 32 288 | 32 979 | 36 623 | 39 773 | 43 221 | 44 708 | 46 315 | 48 723 | 48 571 | 51 636 | 52 596 |
| 1966 | 6 142 | 6 292 | 5 245 | 5 640 | 6 090 | 6 315 | 6 371 | 6 285 | 6 803 | 6 126 | 6 879 | 7 782 | 8 556 | 8 977 | 9 942 | 12 285 | 11 997 | 12 244 | 12 623 | 12 565 | |
| 1967 | 8 819 | 38 053 | 59 404 | 69 273 | 72 413 | 57 839 | 56 343 | 57 446 | 60 790 | 61 606 | 62 963 | 64 704 | 66 452 | 67 610 | 67 283 | 73 671 | 69 470 | 66 986 | 67 311 | | |
| 1968 | 7 992 | 9 232 | 12 249 | 12 860 | 15 348 | 17 530 | 18 577 | 17 475 | 18 069 | 18 280 | 24 533 | 26 381 | 26 900 | 26 572 | 25 811 | 25 641 | 25 906 | 25 216 | | | |
| 1969 | 19 005 | 42 431 | 45 750 | 45 808 | 50 584 | 51 229 | 45 255 | 46 089 | 48 416 | 51 024 | 50 960 | 50 941 | 51 031 | 52 713 | 52 600 | 51 279 | 31 910 | | | | |
| 1970 | 2 662 | 3 131 | 3 233 | 4 049 | 4 992 | 6 131 | 7 201 | 8 593 | 10 908 | 14 606 | 13 174 | 14 558 | 15 352 | 16 515 | 18 816 | 18 560 | | | | | |
| 1971 | 5 224 | 5 973 | 6 337 | 6 531 | 9 001 | 13 004 | 17 844 | 18 490 | 18 856 | 19 347 | 20 708 | 21 237 | 21 708 | 21 886 | 22 302 | | | | | | |
| 1972 | 10 395 | 10 622 | 13 571 | 18 430 | 48 925 | 51 579 | 55 148 | 59 537 | 51 035 | 52 701 | 53 295 | 61 823 | 58 370 | 56 945 | | | | | | | |
| 1973 | 12 702 | 18 366 | 20 396 | 23 617 | 27 675 | 31 983 | 35 327 | 36 608 | 38 186 | 40 871 | 41 313 | 41 346 | 42 657 | | | | | | | | |
| 1974 | 10 748 | 11 455 | 19 975 | 29 037 | 35 914 | 39 252 | 43 649 | 42 330 | 43 924 | 47 033 | 48 636 | 51 338 | | | | | | | | | |
| 1975 | 378 | 8 035 | 8 475 | 13 709 | 13 872 | 13 790 | 14 152 | 17 653 | 18 064 | 18 875 | 19 990 | | | | | | | | | | |
| 1976 | 5 572 | 13 951 | 26 498 | 32 442 | 35 823 | 38 436 | 45 368 | 46 784 | 45 355 | 45 935 | | | | | | | | | | | |
| 1977 | 6 987 | 26 206 | 44 226 | 49 189 | 53 216 | 53 646 | 53 733 | 57 242 | 59 145 | | | | | | | | | | | | |
| 1978 | 2 662 | 12 620 | 14 217 | 21 479 | 26 520 | 29 788 | 34 226 | 40 421 | | | | | | | | | | | | | |
| 1979 | 330 | 9 759 | 15 387 | 27 141 | 27 837 | 28 495 | 28 484 | | | | | | | | | | | | | | |
| 1980 | 2 496 | 5 921 | 9 976 | 12 084 | 15 385 | 20 941 | | | | | | | | | | | | | | | |
| 1981 | 2 066 | 6 485 | 9 189 | 10 757 | 11 632 | | | | | | | | | | | | | | | | |
| 1982 | 652 | 652 | 1 706 | 2 654 | | | | | | | | | | | | | | | | | |
| 1983 | 340 | 933 | 2 941 | | | | | | | | | | | | | | | | | | |
| 1984 | 0 | 2 009 | | | | | | | | | | | | | | | | | | | |
| 1985 | 394 | | | | | | | | | | | | | | | | | | | | |
| CUMULATIVE RATIO | 1.000 | 1.962 | 2.664 | 3.042 | 3.526 | 3.794 | 4.090 | 4.348 | 4.574 | 4.734 | 4.857 | 4.993 | 5.063 | 5.114 | 5.216 | 5.284 | 5.332 | 5.327 | 5.364 | 5.337 | 5.390 |

TABLE G-4 ANTICIPATED APPRECIATION OF INITIAL ESTABLISHED RESERVES OF MARKETABLE GAS AND CORRESPONDING APPRECIATED RESERVES PER EXPLORATORY WELL
As at 31 December 1985

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Discovery Year | Initial Reserves of Marketable Gas | | Year of Discovery to 1985 Year-End | Normal Appreciation[a] | Appreciated Initial Reserves of Marketable Gas | | Appreciated Initial Reserves of Marketable Gas Per Exploratory Well | |
| | $10^6$ $m^3$ | | years | factor | $10^6$ $m^3$ | | | |
| | Annual | Cumulative | | | Annual | Cumulative | Annual | Cumulative |
| Prior to 1951 | | 496 808 | | | | 496 808 | | 415 |
| 1951 | 77 740 | 574 548 | 34 | 1.00 | 77 740 | 574 548 | 169 | 347 |
| 1952 | 91 840 | 666 388 | 33 | 1.00 | 91 840 | 666 388 | 196 | 313 |
| 1953 | 88 473 | 754 861 | 32 | 1.00 | 88 473 | 754 861 | 222 | 299 |
| 1954 | 146 459 | 901 320 | 31 | 1.00 | 146 459 | 901 320 | 417 | 313 |
| 1955 | 88 202 | 989 522 | 30 | 1.00 | 88 202 | 989 522 | 255 | 307 |
| 1956 | 93 805 | 1 083 327 | 29 | 1.00 | 93 805 | 1 083 327 | 244 | 300 |
| 1957 | 110 810 | 1 194 137 | 28 | 1.00 | 110 810 | 1 194 137 | 259 | 296 |
| 1958 | 77 888 | 1 272 025 | 27 | 1.00 | 77 888 | 1 272 025 | 193 | 287 |
| 1959 | 140 578 | 1 412 603 | 26 | 1.00 | 140 578 | 1 412 603 | 325 | 290 |
| 1960 | 49 723 | 1 462 326 | 25 | 1.00 | 49 723 | 1 462 326 | 123 | 277 |
| 1961 | 133 657 | 1 595 983 | 24 | 1.00 | 133 657 | 1 595 983 | 316 | 280 |
| 1962 | 66 614 | 1 662 597 | 23 | 1.00 | 66 614 | 1 662 597 | 138 | 269 |
| 1963 | 72 804 | 1 735 401 | 22 | 1.00 | 72 804 | 1 735 401 | 145 | 260 |
| 1964 | 30 130 | 1 765 531 | 21 | 1.00 | 30 130 | 1 765 531 | 53 | 243 |
| 1965 | 61 996 | 1 827 527 | 20 | 1.00 | 61 996 | 1 827 527 | 88 | 230 |
| 1966 | 22 017 | 1 849 544 | 19 | 1.00 | 22 017 | 1 849 544 | 35 | 215 |
| 1967 | 79 933 | 1 929 477 | 18 | 1.01 | 80 732 | 1 930 276 | 116 | 208 |
| 1968 | 37 236 | 1 966 713 | 17 | 1.01 | 37 608 | 1 967 884 | 40 | 193 |
| 1969 | 64 505 | 2 031 218 | 16 | 1.02 | 65 795 | 2 033 679 | 68 | 182 |
| 1970 | 31 607 | 2 062 825 | 15 | 1.02 | 32 239 | 2 065 918 | 33 | 170 |
| 1971 | 37 704 | 2 100 529 | 14 | 1.03 | 38 835 | 2 104 753 | 41 | 161 |
| 1972 | 77 373 | 2 177 902 | 13 | 1.04 | 80 468 | 2 185 221 | 76 | 154 |
| 1973 | 56 343 | 2 244 772 | 12 | 1.05 | 59 160 | 2 254 908 | 38 | 144 |
| 1974 | 74 361 | 2 319 133 | 11 | 1.07 | 79 566 | 2 334 474 | 64 | 138 |
| 1975 | 45 402 | 2 364 535 | 10 | 1.09 | 49 488 | 2 383 962 | 40 | 131 |
| 1976 | 88 182 | 2 452 717 | 9 | 1.12 | 98 764 | 2 482 726 | 47 | 123 |
| 1977 | 106 085 | 2 558 802 | 8 | 1.16 | 123 059 | 2 605 785 | 53 | 115 |
| 1978 | 90 331 | 2 649 133 | 7 | 1.21 | 109 301 | 2 715 086 | 47 | 109 |
| 1979 | 87 314 | 2 736 447 | 6 | 1.27 | 110 889 | 2 825 975 | 59 | 106 |
| 1980 | 93 394 | 2 829 841 | 5 | 1.37 | 127 950 | 2 953 925 | 56 | 102 |
| 1981 | 65 678 | 2 895 519 | 4 | 1.51 | 99 174 | 3 053 099 | 57 | 98 |
| 1982 | 38 036 | 2 933 555 | 3 | 1.73 | 65 802 | 3 118 901 | 44 | 96 |
| 1983 | 31 628 | 2 965 183 | 2 | 2.10 | 66 419 | 3 185 320 | 56 | 94 |
| 1984 | 28 150 | 2 993 333 | 1 | 2.89 | 81 354 | 3 266 674 | 53 | 93 |
| 1985 | 11 600 | 3 004 933 | 0 | 5.37 | 62 292 | 3 328 966 | 39 | 90 |

a From Figure G-3.

TABLE G-5 SUMMARY OF INITIAL AND REMAINING ESTABLISHED RESERVES OF MARKETABLE GAS AS OF THE END OF EACH YEAR
As at 31 December 1985

| Year | 1 Initial Reserves of Marketable Gas | 2 Annual Marketed Production | 3 Cumulative Marketed Production | 4 Remaining Reserves of Marketable Gas[a] | 5 Remaining Reserves of Marketable Gas at 37.4 MJ/m³ |
|---|---|---|---|---|---|
| | $10^6$ m³ | | | | |
| 1948 | 111 625 | 1 071 | 15 242 | 96 383 | |
| 1949 | 127 994 | 1 155 | 16 397 | 111 597 | |
| 1950 | 144 335 | 1 437 | 17 834 | 126 501 | |
| 1951 | 205 529 | 1 606 | 19 440 | 186 089 | |
| 1952 | 293 376 | 1 803 | 21 243 | 272 133 | |
| June 1953 | 337 299 | 1 916 | 23 159 | 314 140[b] | |
| 1953 | 369 502 | 2 057 | 23 300 | 346 202 | |
| May 1954 | 396 352 | 2 310 | 25 610 | 370 742[c] | |
| 1954 | 428 301 | 2 479 | 25 779 | 402 522 | |
| June 1955 | 455 686 | 1 493 | 27 272 | 428 414[d] | |
| 1955 | 487 607 | 3 015 | 28 794 | 458 813 | |
| Sept 1956 | 535 503 | 2 254 | 31 048 | 504 455[e] | |
| 1956 | 552 154 | 3 240 | 32 034 | 520 120 | |
| 1957 | 617 067 | 3 803 | 35 837 | 581 230 | |
| March 1958 | 659 553 | 1 437 | 37 274 | 622 279[f] | 657 020 |
| 1958 | 727 509 | 5 269 | 41 106 | 686 403 | 721 875 |
| Sept 1959 | 786 026 | 4 818 | 45 924 | 740 102[g] | 781 092 |
| 1959 | 816 003 | 7 128 | 48 234 | 767 769 | 810 263 |
| 1960 | 935 940 | 9 128 | 57 362 | 878 578 | 927 638 |
| 1961 | 949 210 | 11 918 | 69 280 | 879 930 | 931 304 |
| 1962 | 998 937 | 17 581 | 86 861 | 912 076 | 965 058 |
| 1963 | 1 034 746 | 19 637 | 106 498 | 928 248 | 980 848 |
| 1964 | 1 120 649 | 22 088 | 128 586 | 992 063 | 1 053 459 |
| 1965 | 1 210 355 | 24 173 | 152 759 | 1 057 596 | 1 130 525 |
| 1966 | 1 251 010 | 25 526 | 178 285 | 1 072 725 | 1 143 524 |
| 1967 | 1 324 882 | 27 498 | 205 783 | 1 119 099 | 1 190 587 |
| 1968 | 1 459 497 | 30 033 | 235 816 | 1 223 681 | 1 290 070 |
| 1969 | 1 547 006 | 37 809 | 273 625 | 1 273 381 | 1 343 788 |
| 1970 | 1 593 211 | 40 148 | 313 773 | 1 279 438 | 1 353 122 |
| 1971 | 1 638 627 | 48 544 | 362 317 | 1 276 310 | 1 348 074 |
| 1972 | 1 683 875 | 52 404 | 414 721 | 1 269 154 | 1 338 769 |
| 1973 | 1 867 259 | 55 954 | 470 675 | 1 396 584 | 1 465 746 |
| 1974 | 2 014 299 | 57 052 | 527 727 | 1 486 572 | 1 551 552 |
| 1975 | 2 035 120 | 56 573 | 584 300 | 1 450 820 | 1 514 105 |
| 1976 | 2 140 688 | 54 629 | 638 929 | 1 501 759 | 1 565 257 |
| 1977 | 2 268 260 | 60 997 | 699 926 | 1 568 334 | 1 631 749 |
| 1978 | 2 431 556 | 66 406 | 766 332 | 1 665 224 | 1 732 491 |
| 1979 | 2 554 733 | 70 012 | 836 344 | 1 718 389 | 1 784 616 |
| 1980 | 2 647 149 | 63 839 | 900 183 | 1 746 966 | 1 813 657 |
| 1981 | 2 764 103 | 68 632 | 968 815 | 1 795 288 | 1 864 814 |
| 1982 | 2 882 824 | 60 875 | 1 029 690 | 1 853 134 | 1 924 642 |
| 1983 | 2 921 810 | 65 955 | 1 095 645 | 1 826 165 | 1 898 688 |
| 1984 | 2 962 314 | 68 277 | 1 163 922 | 1 798 392 | 1 872 201 |
| 1985 | 3 004 933 | 72 756 | 1 236 678 | 1 768 255 | 1 839 955 |

a Reserve estimates are as of the year-end except where specified otherwise.
b Initial established reserves of marketable gas as of 30 June 1953, less production to 31 December 1952.
c Initial established reserves of marketable gas as of 31 March 1954, less production to 31 December 1953.
d Initial established reserves of marketable gas as of 30 June 1955, less production to 31 December 1954.
e Initial established reserves of marketable gas as of 30 September 1956, less production to 30 June 1957.
f Initial established reserves of marketable gas as of 31 March 1958, less production to 31 December 1957.
g Initial established reserves of marketable gas as of 30 September 1959, less production to 30 June 1959.

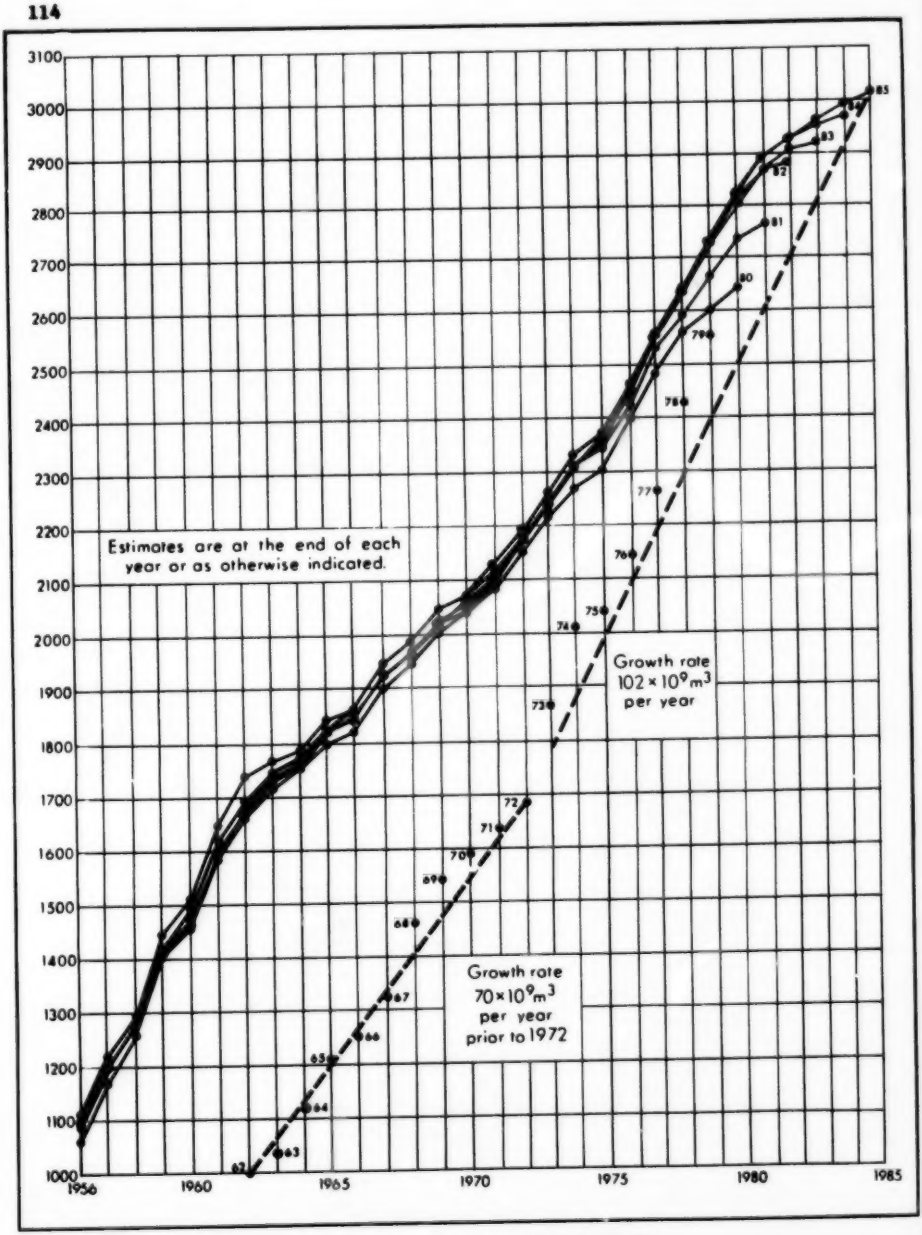



FIGURE G-1 GROWTH OF INITIAL ESTABLISHED RESERVES OF MARKETABLE GAS

ERCB

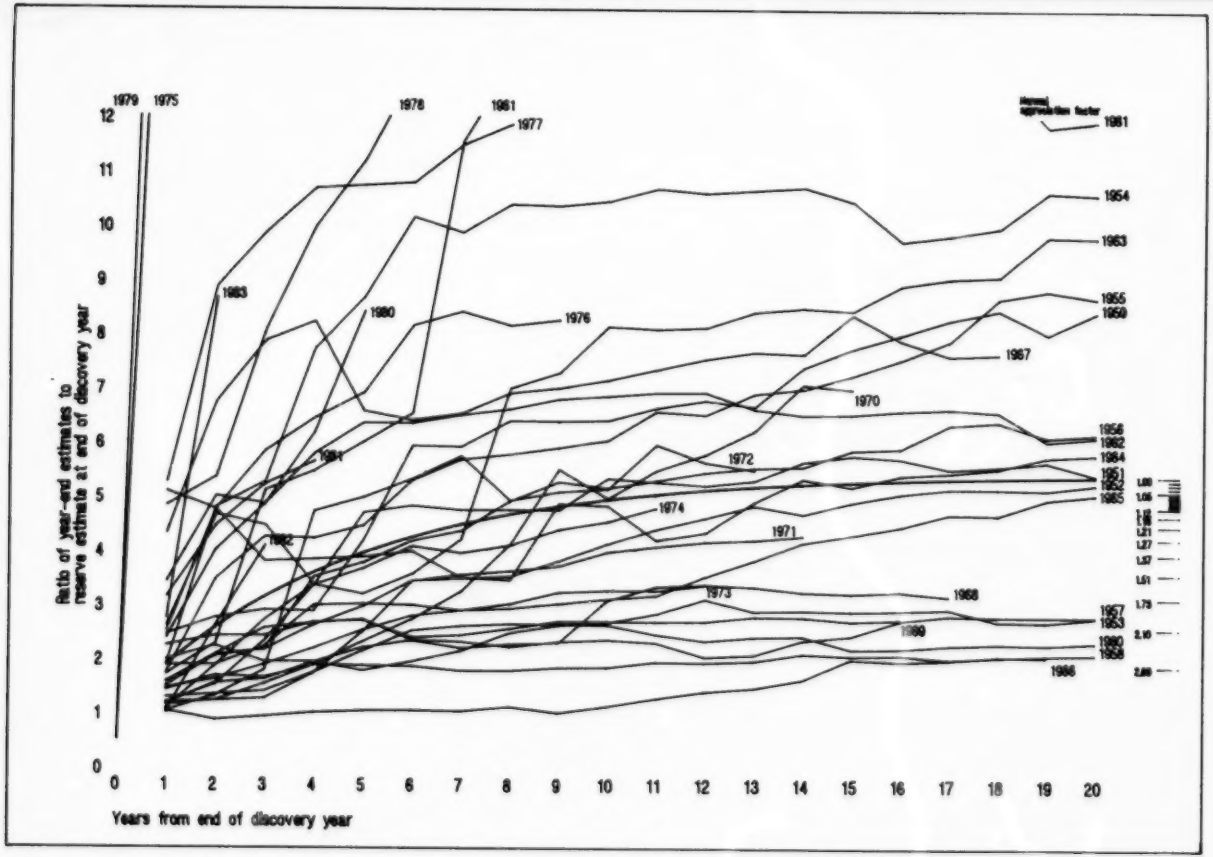



FIGURE G-2 APPRECIATION OF INITIAL ESTABLISHED RESERVES OF MARKETABLE GAS RELATIVE TO RESERVES AT THE DISCOVERY YEAR

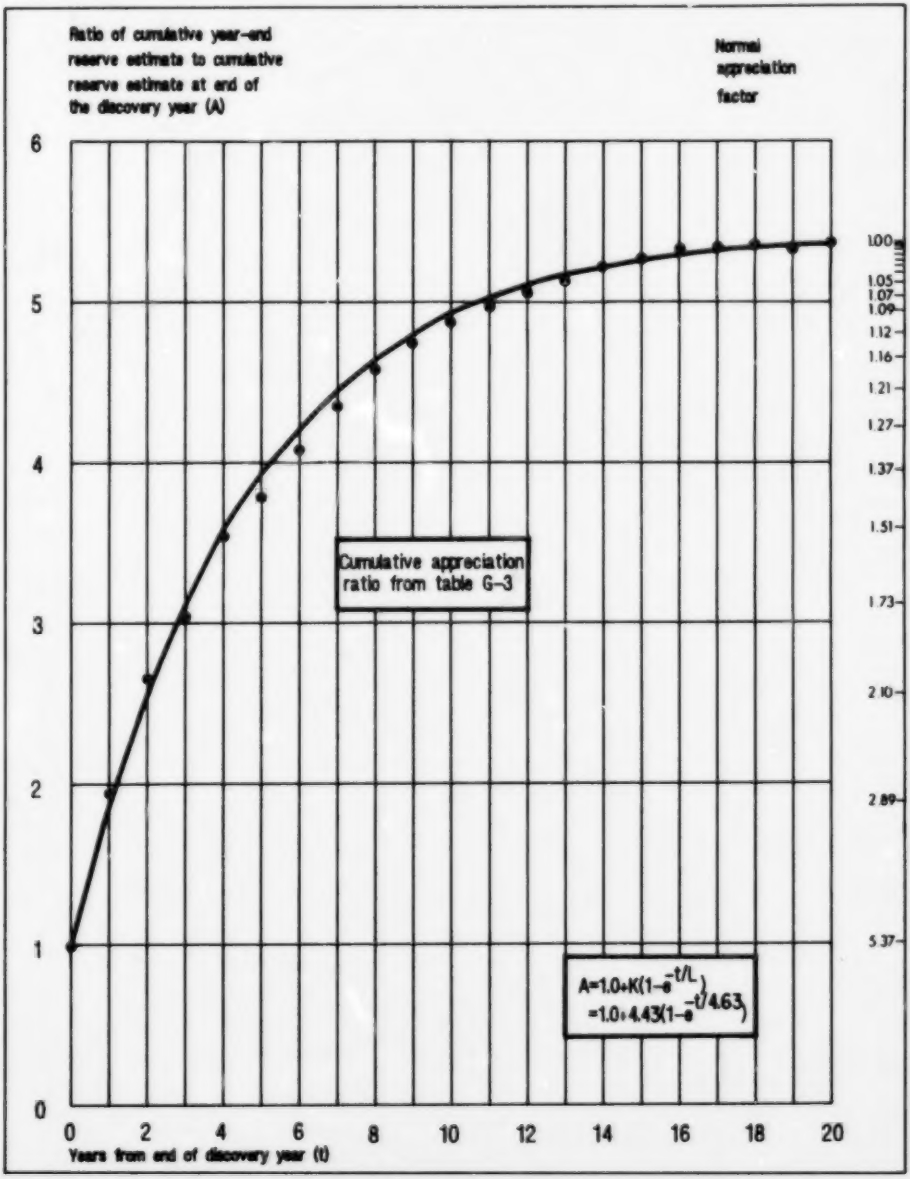



FIGURE G-3 NORMAL APPRECIATION OF INITIAL ESTABLISHED RESERVES OF MARKETABLE GAS

ERCB

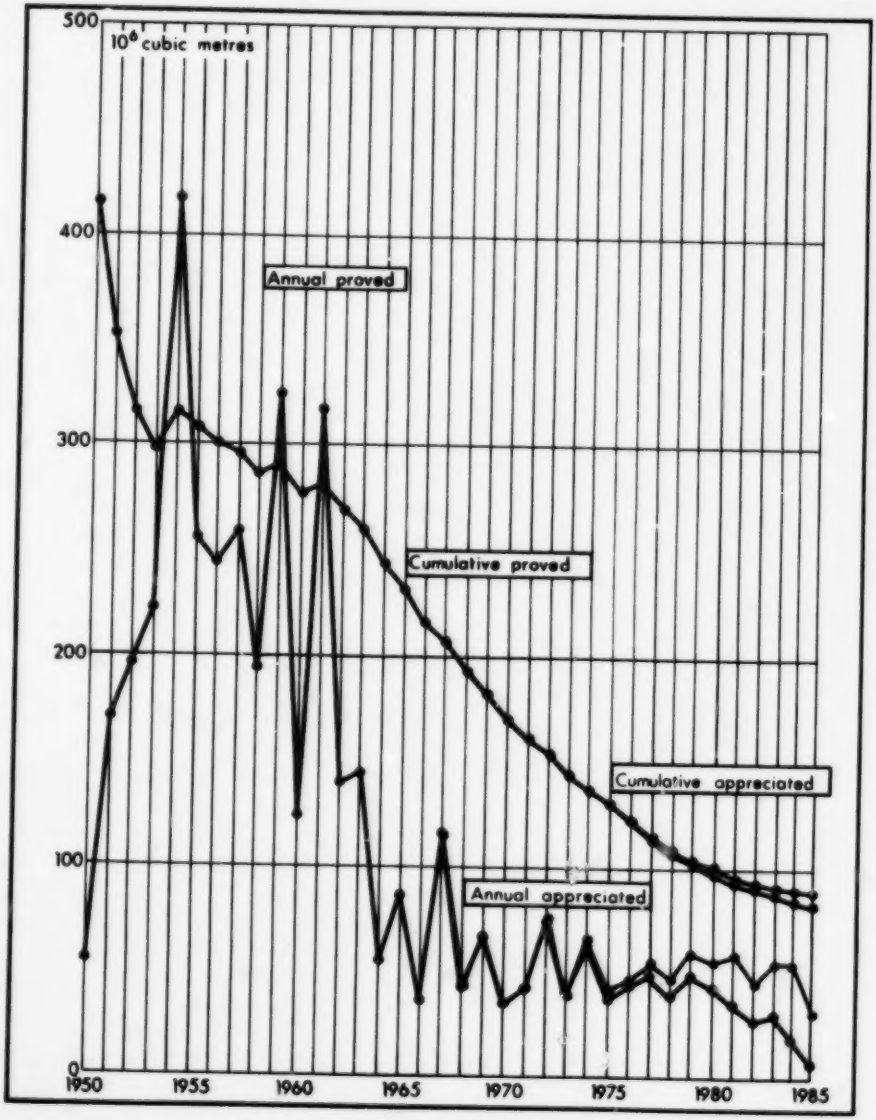



FIGURE G-4 TRENDS IN THE DISCOVERY OF INITIAL ESTABLISHED RESERVES OF MARKETABLE GAS PER EXPLORATORY WELL

ERCB

# APPENDIX E

## DECLINE CURVES

## Appendix E

## DECLINE CURVES

Appendix E contains a series of equations and graphs taken from an article by J. J. Arps entitled, "Estimation of Primary Oil Reserves" in the Society of Petroleum Engineers Publication No. 3, Oil and Gas Property Evaluation and Reserve Estimates, 1970 Edition, Page 31.

| DECLINE TYPE | I. CONSTANT-PERCENTAGE DECLINE | II. HYPERBOLIC DECLINE | III. HARMONIC DECLINE |
|---|---|---|---|
| BASIC CHARACTERISTIC | DECLINE IS CONSTANT<br>$n = 0$ | DECLINE IS PROPORTIONAL TO A FRACTIONAL POWER ($n$) OF THE PRODUCTION RATE<br>$0 < n < 1$ | DECLINE IS PROPORTIONAL TO PRODUCTION RATE<br>$n = 1$ |
| | $D = K q^0 = -\frac{dq/dt}{q}$<br>$\int_0^t D\,dt = -\int_{q_i}^{q_t} \frac{dq}{q}$<br>$-Dt = \log_e \frac{q_t}{q_i}$ | $D = K q^n = -\frac{dq/dt}{q}$<br>FOR INITIAL CONDITIONS<br>$K = \frac{D_i}{q_i^n}$<br>$\int_0^t \frac{D_i}{q_i^n} dt = -\int_{q_i}^{q_t} \frac{dq}{q^n}$<br>$\frac{n D_i t}{q_i^n} = q_i^{-n} - q_t^{-n}$ | $D = K q^1 = -\frac{dq/dt}{q}$<br>FOR INITIAL CONDITIONS<br>$K = \frac{D_i}{q_i}$<br>$\int_0^t \frac{D_i}{q_i} dt = -\int_{q_i}^{q_t} \frac{dq}{q}$<br>$\frac{D_i t}{q_i} = \frac{1}{q_t} - \frac{1}{q_i}$ |
| RATE - TIME RELATIONSHIP | $q_t = q_i \cdot e^{-Dt}$ | $q_t = q_i (1 + n D_i t)^{-\frac{1}{n}}$ | $q_t = q_i (1 + D_i t)^{-1}$ |
| | $Q_t = \int_0^t q_t \cdot dt = \int_0^t q_i \cdot e^{-Dt} \cdot dt$<br>$Q_t = \frac{q_i - q_t e^{-Dt}}{D}$<br>Substitute From Rate - time Equation:<br>$q_t e^{-Dt} = q_t$<br>To Find | $Q_t = \int_0^t q_t \cdot dt = \int_0^t (1 + n D_i t)^{-\frac{1}{n}} \cdot dt$<br>$Q_t = \frac{q_i}{(n-1) D_i} \left[ (1 + n D_i t)^{\frac{n-1}{n}} - 1 \right]$<br>Substitute From Rate - time Equation:<br>$(1 + n D_i t) = \left(\frac{q_i}{q_t}\right)^n$<br>To Find | $Q_t = \int_0^t q_t \cdot dt = \int_0^t q_i (1 + D_i t)^{-1} \cdot dt$<br>$Q_t = \frac{q_i}{D_i} \left[ \log_e (1 + D_i t) \right]$<br>Substitute From Rate - time Equation:<br>$(1 + D_i t) = \frac{q_i}{q_t}$<br>To Find |
| RATE - CUMULATIVE RELATIONSHIP | $Q_t = \frac{q_i - q_t}{D}$ | $Q_t = \frac{q_i^n}{(1-n) D_i} \left( q_i^{1-n} - q_t^{1-n} \right)$ | $Q_t = \frac{q_i}{D_i} \log_e \frac{q_i}{q_t}$ |

$D$ = Decline as a fraction of production rate
$D_i$ = Initial decline
$q_i$ = Initial production rate
$t$ = Time
$q_t$ = Production rate at time $t$
$Q_t$ = Cumulative oil production at time $t$
$K$ = Constant
$n$ = Exponent

FIG. 3—CLASSIFICATION OF PRODUCTION DECLINE CURVES.

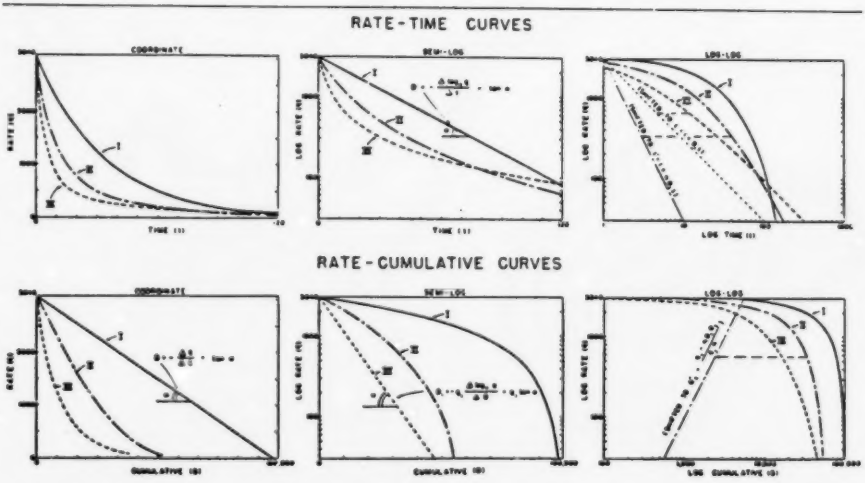

RATE-TIME CURVES
RATE-CUMULATIVE CURVES
I ——— CONSTANT PERCENTAGE DECLINE n = 0 D = .03
II ——— HYPERBOLIC DECLINE n = ½ D = .10
III ------- HARMONIC DECLINE n = 1 D = .30
II' — · — HYPERBOLIC DECLINE (SHIFTED ON LOG - LOG)
III' ------ HARMONIC DECLINE (SHIFTED ON LOG - LOG)

FIG. 4—THREE TYPES OF PRODUCTION DECLINE CURVES ON COORDINATE, SEMI-LOG AND LOG-LOG GRAPH PAPER.

# APPENDIX F

## CLASSIFICATION AND NOMENCLATURE SYSTEMS

## Appendix F

## CLASSIFICATION AND NOMENCLATURE SYSTEMS

Appendix F contains recommended definitions, taken from the Study Group Report of the World Petroleum Congress, on Classification and Nomenclature Systems for Petroleum and Petroleum Reserves.[1] The following is an excerpt from that publication:

### 2.2 Recommended Definitions

**Petroleum** is a naturally occurring mixture of predominantly hydrocarbons in the gaseous, liquid or solid phase.

**Hydrocarbons** are chemical compounds consisting wholly of hydrogen and carbon.

**Crude Oil** is the portion of petroleum that exists in the liquid phase in natural underground reservoirs and remains liquid at atmospheric conditions of pressure and temperature. Crude oil may include small amounts of non-hydrocarbons produced with the liquids. Crude oil has a viscosity of less than or equal to 10 000 millipascals per second (mPa • s)* at original reservoir conditions.

**Natural Gas** is the portion of petroleum that exists in the gaseous phase or is in solution in crude oil in natural underground reservoirs, and which is gaseous at atmospheric conditions of pressure and temperature. Natural Gas may include amounts of non-hydrocarbons.

**Natural Gas Liquids** are those portions of Natural Gas which are recovered as liquids in separators, field facilities or gas processing plants. Natural Gas Liquids include but are not limited to ethane, propane, butanes, pentanes, natural gasoline and condensate; they may include small quantities of non-hydrocarbons.

**Natural Tar** is the portion of petroleum that exists in the semi-solid or solid phase in natural deposits. In its natural state it usually contains sulphur, metals and other non-hydrocarbons. Natural Tar has a viscosity greater than

*The mPa • s, an SI derived unit for dynamic viscosity, equals the centipoise (CP), a CGS unit of measurement of general usage in the oil industry.

10 000 mPa • s (centipoises) measured at the conditions of pressure and temperature in the deposit. Natural Tar generally requires upgrading prior to normal refining.

### 2.3.1 Crude Oil

Crude oils are sometimes called **Sour** or **Sweet**, according to the content of sulphur compounds, which usually have distinctive odours, cause corrosion and so have an adverse environmental impact. There are no criteria generally used on a world-wide basis to differentiate between sour and sweet crude oils.

Similarly, although sometimes crude oils are classified as **Waxy** or **Non-Waxy**, there are no generally accepted criteria for this differentiation.

The term **Non-Conventional**, as applied to crude oils, is now less frequently used, referring in some instances to its type of occurrence or extraction, in others to its processing or refining, and in still others to both operations. It might be said generally that "non-conventional crude oils" is used in some countries for extra-heavy oil or natural tar.

### 2.3.2 Natural Gas

In addition to natural gas as described in the basic definitions, there are a number of classifications and other related terminology that should be discussed to ensure consistency in the exchange of information.

**Raw Natural Gas** is natural gas as it is produced from the reservoir that includes varying amounts of the heavier hydrocarbons which liquefy at atmospheric conditions, water vapour, sulphur compounds, such as hydrogen sulphide, and other non-hydrocarbon gases, such as carbon dioxide, nitrogen or helium. This gas is not suitable for direct utilization by most types of consumers. It is common practice to include as Natural Gas those occurrences with a high percentage of non-hydrocarbon gases, but which, nevertheless, are exploitable for their hydrocarbon content.

**Marketable Natural Gas** is gas available for sale, for direct consumption as a domestic, commercial or industrial fuel, or as an industrial raw material, whether it occurs naturally or results from the processing of Raw Natural Gas. Marketable Natural Gas has to meet certain minimum specifications which vary from case to case. Within such specifications, the gas composition may vary with respect to

the content of the heavier hydrocarbons and non-hydrocarbon gases, which do not render the gas unmarketable. Consequently, the heating value of Marketable Natural Gas may vary considerably and therefore quantities are usually expressed not only in volumes, but also in terms of energy content.

**Wet (Rich) Gas** refers to natural gas containing hydrocarbons heavier than methane in such quantities that they may be extracted commercially, or that may require extraction to render the residue gas suitable for fuel use.

**Dry (Lean) Gas** is natural gas containing insufficient quantities of hydrocarbons heavier than methane to allow their commercial extraction or to require their removal in order to render the gas suitable for fuel use or pipeline transit. There are no universal classification standards of natural gas as 'wet' or 'dry'.

Raw natural gas may also be categorized depending on its contents of hydrogen sulphide or other sulphur compounds. **Sweet Natural Gas** contains no sulphur or sulphur compounds at all, or in such small quantities that no processing is necessary for its removal in order that the gas may be used directly as a non-corrosive domestic heating fuel. **Sour Natural Gas** requires processing for the removal of sulphur and sometimes of carbon dioxide.

The mode of occurrence of natural gas also features in classifications that are often referred to. **Non-Associated Gas** occurs in a natural reservoir not in contact with crude oil, while that which is in contact with or dissolved in crude oil is termed **Associated Gas**. Associated gas can be further categorized as **Gas-Cap Gas** being that which exists in the reservoir in the gaseous phase but in contact with crude oil, and **Solution Gas** being that which is dissolved in the crude oil at reservoir conditions.

A distinction which is occasionally made with respect to natural gas relates to the type of occurrence. **Conventional Gas** refers to natural gas occurring in a normal porous and permeable reservoir rock, either in the gaseous phase or dissolved in crude oil, and which technically can be produced by normal permeation practices. **Non-Conventional Gas** may be natural gas found in very impermeable reservoirs which require uneconomic reserve stimulation in order to be recovered, or gas contained in or around occurrences of gas hydrates, or gas dissolved in formation rock, or gas from artificial **in situ** gasification of coal.

None of these occurrences are known to be exploited commercially, as yet, although various pilot projects have been tried for some time.

Natural gas, for ease of transportation in some cases, is increasingly being liquefied by lowering its temperature, and is then termed **Liquefied Natural Gas** (LNG).

### 2.3.3. Natural Gas Liquids

It is common practice in the oil industry to refer in a number of ways to components considered to be Natural Gas Liquids. A detailed classification of the term is useful.

**Gas Plant Products** are natural gas liquids recovered from natural gas in gas processing plants and, in some situations, from field facilities. Gas plant products include ethane, propane, butanes, butane-propane mixtures, natural gasoline and plant condensates.

**Liquefied Petroleum Gases** (LPGs) is a term commonly used to refer to mixtures consisting predominantly of butanes and propane.

**Condensates** are the natural gas liquids, consisting mostly of pentanes and heavier. In the USA these include **Lease Condensates**, recovered from gas-well gas (associated and non-associated) in gas-liquid separators or field facilities, and **Plant Condensate**, recovered in a plant for natural gas gathering, compression and associated gas treating systems. Lease Condensate may, in some circumstances, be mixed with crude oil for marketing. Plant Condensate is not suitable for blending with natural gasoline or refinery gasoline....

## 3.2 Recommended Nomenclature System for Petroleum Reserves

**Proved Reserves** of petroleum are the estimated quantities, as at a specific date, which analysis of geological and engineering data demonstrates, with reasonable certainty, to be recoverable in the future from known reservoirs under the economic and operational conditions at the same date.

**Proved Developed Reserves** are those Proved Reserves that can be expected to be recovered through existing wells and facilities and by existing operating methods. Improved recovery reserves can be considered as Proved Developed Reserves only after an improved recovery project has been installed.

**Proved Undeveloped Reserves** are those Proved Reserves that are expected to be recovered from future wells and facilities, including future improved recovery projects which are anticipated with a high degree of certainty.

**Unproved Reserves** of petroleum are the estimated quantities, as at a specific date, which analysis of geological and engineering data indicate might be economically recoverable from already discovered deposits, with a sufficient degree of certainty to suggest the likelihood or chance of their existence.

Unproved Reserves may be further categorized as **Probable Reserves** where there is a likelihood of their existence, or **Possible Reserves** where there is only a chance of their existence.

The estimated quantities of Unproved Reserves should take account of the uncertainties as to whether, and to what extent, such additional reserves may be expected to be recoverable in the future; the estimates, therefore, may be given as a range....

**Speculative Reserves** of petroleum are the estimated quantities, as at a specific date, which have not yet been discovered, but which general geological and engineering judgment suggests may be eventually economically obtainable. Due to the great uncertainties, they should always be given as a range.

**Petroleum-in-Place** is the total quantity of petroleum that is originally estimated to exist in naturally occurring reservoirs.

**Future Potential Recovery**, at a specific date, is the sum of the Proved Reserves, the Unproved Reserves and the Speculative Reserves. Due to the great uncertainties in the estimation of some of the components, the estimates should always be expressed as a range.

**Ultimate Potential Recovery**, as at a specific date, is the sum of Cumulative Production and Future Potential Recovery.

**Primary Recovery** is the production of petroleum from naturally occurring reservoirs utilizing the natural energy available in the reservoirs to move fluids through the reservoir rock to well bores or other points of recovery.

**Improved Recovery** is the production of petroleum from naturally occurring reservoirs by supplementing the natural energy or altering the natural forces of the reservoirs.

[1]World Petroleum Congress Study Group Report, Classification and Nomenclature Systems for Petroleum and Petroleum Reserves. John Wiley and Sons Ltd., New York, 1984.

November 1986

**CANADIAN ENERGY RESEARCH INSTITUTE**

**PUBLICATIONS FROM JANUARY 1983 TO DATE**
(A Complete List of CERI Publications
is Available Upon Request)

Studies

No. 17 Energy and Regional Investment in Canada. Gordon W. Douglas and Ellen F. Battle. March 1983 (Price $20.00, 114 pages) ISBN 0-920522-28-9.

No. 18 Household Energy Savings: Options for the Future. Brian D. Sumner and Barbara E. Green. March 1983 (Price $20.00, 194 pages) ISBN 0-920522-27-0.

No. 19 Modelling Exploration Success in Alberta Oil Plays. Kenneth D. Foat and Alan J. MacFadyen. September 1983 (Price $15.00, 181 pages) ISBN 0-920522-29-7.

No. 20 The Oil and Gas Investment Climate: Changes Over a Decade. DataMetrics Limited. June 1984 (Price $15.00, 76 pages) ISBN 0-920522-31-9.

Appendix Volume to Study No. 20. The Oil and Gas Investment Climate: Changes Over a Decade. DataMetrics Limited. June 1984 (Price $12.00, 141 pages).

No. 21 Canadian and U.S. Heavy Crude Oil Markets: A Review and Prospects. Volume I. Canadian Energy Research Institute. April 1985 (Price $25.00, 175 pages) ISBN 0-920522-36-X.

Appendix Volume to Study No. 21. Canadian and U.S. Heavy Crude Oil Markets: A Review and Prospects. Volume II. Canadian Energy Research Institute. April 1985 (Price $10.00, 133 pages).

No. 22 Natural Gas for Vehicles in Canada: A Study of Market Penetration Problems. Brian D. Sumner. April 1985 (Price $20.00, 99 pages) ISBN 0-920522-37-8.

No. 23 Energy Efficiency in Canada's Pulp & Paper Industry. Ellen F. Battle. October 1986 (Price $35.00, 131 pages) ISBN 0-920522-38-6.

## Research Reports

83-1 Potential Benefits and Costs of Canadian Electricity Exports. Ellen F. Battle, Gordon S. Gislason, and Gordon W. Douglas. April 1983 (Price $25.00, 288 pages) ISBN 0-920522-26-2.

84-1 The Costs of Transportation Fuel from Methanol versus Oil Sands. Brian D. Sumner, Tricia Gibson, and Z. Charles Slagorsky. December 1984 (Price $20.00, 100 pages) ISBN 0-920522-34-3.

85-1 The Wolf Lake Project: An Example of Benefits to the Canadian Economy from Commercial Oil Sands Development. Louise Czaja, Michael Kirkegaard, Walter Haessel and Gordon Douglas. March 1985 (Price $10.00, 67 pages).

85-2 Estimated Petroleum Finding Costs in Alberta, 1970-1983. Z. Charles Slagorsky and Janice L. Pasay. October 1985 (Price $15.00, 62 pages).

86-1 The Effect of the Western Accord and Recent Provincial Royalty Changes on Petroleum Industry Capital Expenditures. Janice L. Pasay. March 1986 (Price $15.00, 27 pages).

86-2 Reserves of Hydrocarbons in Alberta: A Review of Canadian Petroleum Association and Alberta Energy Resources Conservation Board Estimates and Methodology. James N. Tanner. November 1986 (Price $25.00, 130 pages) ISBN 0-920522-39-4.

## Working Papers

83-1 Development Options for Maritime Coal. John A. Dawson. January 1983 (Price $7.50, 42 pages).

83-2 Development Options for Alberta and Saskatchewan Coal. Tricia Gibson. March 1983 (Price $7.50, 44 pages).

83-3 Development Options for British Columbia Coal. Kristi E. Varangu. April 1983 (Price $7.50, 107 pages).

83-4 The Impacts of Crude Oil Supply Changes and Supply Allocation. Douglas J. Haughey and Donald A. Bruton. May 1983 (Price $7.50, 72 pages).

83-6 The Potential for Energy Substitution in Canada. Brian D. Sumner. September 1983 (Price $7.50, 124 pages).

Working Papers

84-1 A Review of Oil and Gas Drilling Activity Forecasting Techniques. G. E. Angevine, S. R. Cain, and Z. C. Slagorsky. March 1984 (Price $5.00, 20 pages).

84-2 An Assessment of Benefits and Costs of Using Methanol as a Motor Gasoline Extender in Southern Ontario. Walter Haessel and Tricia Gibson. September 1984 (Price $10.00, 62 pages).

84-3 The CERI Energy Pricing and Demand Models: A Description and Internal Evaluation. L. A. Coad. October 1984 (Price $10.00, 45 pages).

85-1 The Implications of Canadian Natural Gas Deregulation. Douglas J. Haughey and Robert T. Liddle. January 1985 (Price $10.00, 97 pages).

85-2 A Partial Regional Comparison of Taxes and Subsidies on Natural Gas, Electricity, and Oil Products in Canada. L. Coad and K. Desbarats. May 1985 (Price $10.00, 78 pages).

Discussion Papers

83-1 The Alberta New Oil Royalty Formula: 74-04-01 to 82-12-31. Alan R. Webster. March 1983 (Price $6.00, 56 pages).

Presentations by Staff (available upon request)

83-1 Household Energy Costs: Recent Developments and Options for the Future. G. E. Angevine. Notes for Remarks at the "New Neighbourhood Forum," sponsored by the Ontario Ministry of Housing and Municipal Affairs, Toronto, January 31, 1983.

83-2 Net Regional and National Benefits of Canadian Electricity Exports. Gordon S. Gislason, Ellen F. Battle, and Gordon W. Douglas. Paper presented to the Canadian Electrical Association Generation System Planning and Operation Subsection, Vancouver, March 21, 1983.

83-3 Economic and Financial Implications of Lower Oil Prices. Walter Haessel. Paper presented at a conference on The Impact of Lower Oil Prices, sponsored by Data Resources of Canada, Sheraton Centre, Toronto, April 14, 1983.

83-4 Energy Pricing in the World and Canada. James A. MacMillan. Paper presented to the Canadian Chapter of the International Association of Energy Economists, Toronto, May 20, 1983.

83-5 Canadian Energy Issues and Outlook. Douglas J. Haughey. Paper presented to the Institute of Internal Auditors, Calgary, October 18, 1983.

84-1 The CANREM Model: Model Structure, User Experience and Potential Applications. Gordon W. Douglas, Gordon S. Gislason, and Ellen F. Battle. Presentation to the Canadian Electrical Association Meetings, Edmonton, March 15, 1984.

84-2 Canadian Electricity Exports: The New Opportunities. Ellen F. Battle and Gordon W. Douglas. Presentation to the International Association of Energy Economists, San Francisco, November 6, 1984.

85-1 CANREM: An Integrated Model of Electric Utility Planning Processes. Gordon W. Douglas, Vaffi H. Poonja, and Ellen F. Battle. Presentation to the Canadian Operational Research Society, Halifax, May 23, 1985.

Proceedings

International Gas Markets Conference. Proceedings of a Conference held on September 26, 1983, Calgary, Alberta. Edited by Shane Streifel. (Price $45.00, 247 pages) ISBN 0-920522-33-5.

Annual Report

Board of Directors' Report for the Year Ended March 31, 1985.